A MANUAL

OF

THE GEOLOGY OF INDIA.

PART III.

ECONOMIC GEOLOGY,

BY

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1850

Published by order of the Government of India.

CALCUTTA:

SOLD AT THE

OFFICE OF THE GEOLOGICAL SURVEY OF INDIA;

AND BY ALL BOOK-SELLERS.

LONDON: TRÜBNER & CO.

MDCCCLXXXI.

Price Rs. 5.

CALCUTTA:
PRINTED BY THE SUPERINTENDENT OF GOVERNMENT PRINTING,
8, HASTINGS STREET.

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PREFACE.

THE geologist has an anxious part to play with reference to practical questions. He is instituted more as a concession to what seems but a rising fashion, than from any faith in his knowledge or any understanding of his functions; and thus it happens that he is not consulted when his opinion might be of great service, or, on the other hand, he is called upon to perform what is quite out of his line of business, or twitted for not having done what it would be unwise to attempt unless under special circumstances, and impossible to undertake without special appliances that were not at his disposal. As no one is more aware than himself that the best, if not the only, warrant for his existence is his usefulness, such circumstances are very distressing. The martyr's hope is sometimes his only consolation—that there is surely a better time about to dawn, when knowledge will prevail among the people.

The geological survey of India had its origin in the desire of Government to have the coal-fields of this country systematically investigated, and the work of the survey was for some time wholly devoted to this task. It was only after the principal coal-fields had been mapped and described, or were well in hand, that the general examination of the

geology of India was taken up, an increase to the staff having been sanctioned for the purpose. We were thus able within a reasonable time to prepare a general geological sketch map of nearly the whole of India, a descriptive account of which is given in the two first parts of this Manual, published in 1879. A corresponding summary of the mineral resources of India was, of course, part of the design for that work; but as the least attractive part of the performance it was postponed under various pretexts more or less justifiable.

Dissatisfaction with the best account that could be given was a chief cause of reluctance. What real information we possessed was already published in greater fulness than could be rendered in a summary for the whole of so great an area; and that information related almost entirely to coal and iron; for the rest there were in most cases only dry facts, insufficient for any safe practical judgment. I cannot now explain why, in the nature of the things, this contrast obtains—why the naturally exposed evidence of vein deposits (from which most metals are derived) is very much less satisfactory than in the case of stratified deposits, but so it is: without more or less extensive surface clearings or trial sinking it is seldom possible to give an opinion worth having on a mineral lode. It has very rarely (and with sufficient reason) been the desire of Government to undertake this preliminary mining or 'prospecting'; and there are as yet no mining operations in this country from which it would be possible to learn something of the habits of mineral deposits in our Indian rocks, the indigenous workings which were once active having long since been abandoned. Except in the case of the precious metals, the mere fact of former workings covering a large extent of ground gives very little security as to the strength of the ore, for it is certain that with his small 'plant' and low demands the native can derive profit when larger works would fail.

Thus it happens that the information available regarding metalliferous deposits in India (iron excepted) is defective in respect of their probable value, although the dry facts of the occurrence of ores in many places are abundant enough. A complete collection of those isolated observations involved long and patient search through many papers published and unpublished. This task has now been very thoroughly accomplished by Mr. Ball: in this 3rd Part of the Manual of the Geology of India he has colligated all the scattered information in groups of subjects and of districts, indicating the relations to what is known of the geology of the country. The student as well as the man of enterprise will long owe him gratitude for the great store of facts thus brought within easy reference.

H. B. MEDLICOTT,

Superintendent,
Geological Survey of India.

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INTRODUCTION.

India "*has underground numerous veins of all sorts of metals, for it contains much gold and silver and copper and iron in no small quantity, and even tin and other metals which are employed in making articles of use and ornament as well as the implements and accoutrements of war.*"

The above is a description of India as it was known in the time of Megasthenes[1] or nearly 300 years B. C. To many it may appear that it was a fanciful and fabulous India, very different from the country as it is now known to us. To such the facts set forth in this work not only as to the extent of the mineral resources, but also as to the extent of the ancient mining operations, will come almost as a revelation.

The habit of speaking contemptuously of the mineral deposits of the country having grown up so strongly the question of the value of particular deposits is now far too often unfavourably prejudged. Speaking generally, the value of the majority of the deposits is relative to external circumstances. Were India wholly isolated from the rest of the world, or were her mineral productions protected from competition, there cannot be the least doubt that she would be able, from within her own boundaries, to supply very nearly all the requirements, in so far as the mineral world is concerned, of a highly civilised community. But the consumer would probably have to pay more than he does at the present day.

Many of the deposits of metallic ores are undoubtedly poor from the point of view of the European miner, still the Native miner and smelter, by an enormous amount of very hard work, were enabled to produce the metals which they sold at very high prices; but the production per man was so small that these artizans managed only to secure for themselves a scanty subsistence. As foreign competition has enabled the merchant to sell the metals at the very mines at a lower price, the trades of the indigenous miner and smelter have been, as regards those who worked all the metals, except iron, almost completely crushed out of existence. In the introductory remarks to the Chapter on Iron, it will be seen that that particular industry has also become extinct throughout large tracts of India, and that in the remainder it is only kept alive by a hard struggle.

[1] Ancient India, by J. W. McCrindle, M.A., p. 31.

As English lead and English copper have undersold the indigenous metals at their places of production, so English iron has supplanted native iron in many parts of the country and bids fair, provided an easily malleable iron can be sold at a cheap rate, to do so in all.

Casual readers of this volume might perhaps pass over the tables given in the appendices were their attention not specially directed to them. That the facts they contain are of the highest importance in connection with the question of the development of the indigenous mineral resources of India will be apparent from the following abstract statement of the value and amount of imports for the official year 1879-80 :—

	Quantity.		Value. Rs.
Precious stones (including pearls)	...		15,52,799
Coal, coke and patent fuel[1]	6,08,760	tons	1,17,40,715
Petroleum	78,88,247	gals.	48,19,079
Sulphur	13,319	cwt.	81,290
Arsenic	300	,,	5,256
Mercury	5,31,393	lbs.	5,88,436
Gold (including coin)	...		2,05,03,929
Silver ,, ,,	...		9,60,50,019
Copper ,, ,,	3,86,173	cwt.	1,62,01,547
Brass	10,279	,,	5,38,484
Lead	73,480	,,	10,62,958
Zinc	1,27,138	,,	14,43,599
Tin	20,840	,,	9,88,459
Iron[2]	21,11,156	,,	1,22,93,847
Lime and Chalk	43,739	,,	19,294
Salt	3,52,238	tons	76,25,321
Saltpetre	3	cwt.	49
Borax	34	,,	922
Building stones, millstones, grindstones, &c.	17,423	,,	93,414
	TOTAL		17,56,09,427
	Or in sterling at par		£17,560,942-14

An attempt has been made in the following pages to gather up the almost forgotten and nearly lost shreds of information regarding the mineral deposits of India as they were known in early times, and to interweave them with the facts acquired in recent years, so producing a united and continuous whole.

[1] Taken from Appendix B, includes imports by Government.

[2] Exclusive of imports by Government which are apparently not yet published.

By the light of modern knowledge it is possible to read many allusions as to the existence of mineral productions in India, which were hitherto obscure. It will be shown that India has not only produced gold since the very earliest times of which there is any record, but that there were also, in all probability, mines from which silver was obtained in some quantity.

Hitherto mining for metallic ores by British companies has not been successful in this country, though coal and salt-mining and the quarrying of building materials have been carried on either by the Government or by private companies with, in many cases, very great profit. It would seem, however, that, as regards the metals, there is a new era about to commence, and that the capabilities of India, not only as a gold-producing country, but also in reference to other metals, will in the course of the next few years be for the first time fairly tested.

Looking over the scattered records of the early discoveries of minerals in India since the British occupation, one cannot but be struck with the evidence they afford that history repeats itself. Specimens, say, of gold, copper and lead ores or coal were found often in the first instance by natives. Samples forwarded by district officials to Government were assayed and gave rise to a more or less voluminous correspondence. Where the district officials were much interested in the discovery, small grants of money were occasionally made in order to test the value of the deposits. These grants were in not a few cases expended in grubbing and rooting away at the outcrop of the mineral, as though the deliberate intention had been to remove every trace of it, and thus it has happened that when such localities have been visited by professional experts nothing but a heap of debris remained to bear testimony to the fact of money having been spent. For the removal of the debris neither funds nor time might be available, but in some cases the same deposits have more than once been thus treated, the memory of former operations having passed away, and on each occasion a *new* discovery has been announced.

One of the objects of this work is to rescue from the oblivion in which they have long been enveloped and trace historically the early notices of such discoveries. Some of them are to be found in old manuscripts, others in papers published in various journals which are not now—and some of them never were—easy of access to by the Indian public. The volumes which have been consulted in this search amount to many hundreds, and no pains have been spared to extract from each paper as much of the information of value which it contains as is consistent with a due regard for brevity. The full references to these sources of information which are

given in an appendix will enable those who may be interested in any particular deposit to have recourse to the originals, should they desire further details than it is possible to include in a *précis*.

There may be important deposits of metalliferous ores which have not yet come to light; in fact that this is so is certain to be the case, but that mere superficial exploration, without aid from artificial cuttings for canals or railways or from the laying bare of natural sections by landslips, will add many completely new localities to those where such deposits are known to occur, is less probable than might be supposed, and for this reason: the Indian peasantry are observant and curious about these matters, and in most cases where it has been possible for them to make anything out of such deposits they have done so in a small way. From time immemorial, too, the country has been traversed over by peripatetic metallurgists, the workers in iron, and through their agency deposits have been brought to light, the knowledge of which has become public property through the agency of district officials; of course as to the actual extent of such deposits where they have not been visited or reported on by experts, our knowledge, even as regards the mere superficial appearances, is in many cases very defective, while, regarding the majority of the others, we simply have no information as the result of actual workings.

Insensate attacks are sometimes made against the small body of officers which constitutes the Geological Survey of India for not having brought to light the presence of minerals which are sometimes claimed to be discovered by others. It is perhaps not too much to say that a majority of such discoveries turn out to be delusions. Even were it not so, it is impossible for Indian geologists, who in their season's work traverse enormous areas, to go over every inch of ground. And this fact, moreover, should be borne in mind, that the natives, in many parts of India, are unwilling to disclose the mineral resources of their country to strangers, and, in some cases, they actually take steps to prevent their discovery, as will be illustrated in the course of the following pages.

That residents for months and years in a neighbourhood to which a geologist has only been able to devote, perhaps, a day or two should make discoveries would not be surprising, but it is surprising that such discoveries are not more common. It is competent for geologists to demonstrate the possibility of certain minerals occurring in certain tracts, and the utter futility of searching for others in areas where the geological formation precludes the possibility of their occurrence.

That the records of the Geological Survey, and the information avail-

able regarding the mineral deposits of this vast country, are even more extensive than could have been expected under the circumstances will, it is believed, be admitted by all candid readers of this volume. For those who declaim, without first referring to the available sources of information, no specific can be offered—they are past treatment. It is hoped that those who have opportunities, and are otherwise competent to do so, will contribute to the general store of information; and this volume will, it is believed, suffice to show both what is already known, and the points which need further investigation. If it should succeed in eliciting facts in the same manner as several manuals on other branches of natural science in India have done, it will have fulfilled one main object which the author has kept steadily in view.

Even with increased information it may be possible hereafter to issue a very much condensed edition of this work, but at present it seemed to be desirable to place within the reach of the residents of every district in India as full a digest as possible of what is recorded regarding their respective areas. At the present stage of our knowledge, where so little has been done by actual mining operations, we are not in a position to adopt a strictly censorial style, and reject as utterly worthless of mention deposits at localities where only mere traces of ore are known to exist. It appears, therefore, to be a far safer and more useful plan to state exactly what has been recorded, leaving it to possible future exploration to determine doubtful questions as to value.

Owing to the extent of the matter it has been thought to be best not to introduce extraneous, though really often both interesting and important, subjects, such as comparisons with the mode of occurrence of similar minerals in other countries; nor has much space been devoted to subjects which can be found fully discussed in ordinary manuals of Mineralogy.

In order to avail of this work most effectually, the reader should bear in mind that there is a double system of arrangement,—a vertical one by subjects, and a horizontal one by districts. A glance at the first part of the index will show in what districts of India a particular mineral is to be found, or, on the other hand, the second part will show what are the mineral productions of any particular district.

The maps are not so numerous as was originally intended; but in dealing with such large areas there are great difficulties in the preparation of maps of sufficient size to be useful. Those of the principal diamond-bearing areas will, it is thought, have a special interest as they have never before been published on the same scales. The map of the Wynaad has not been very successful; it was hoped when it was

commenced that information bringing it up to date would be forthcoming, but it had not been received at the time of going to press The map of the coal-fields, though merely an index to the larger-scale maps of the separate fields which have been published by the Geological Survey, cannot fail to prove useful with reference to the alignment of new lines of railway through the country. The General map of India is included for the convenience of those who are not well acquainted with the relative positions of the different provinces into which India is subdivided.

The plates have been taken from photographs and sketches, and they serve to illustrate some of the native methods of mining and metallurgy which are destined to become extinct.

At first it was intended in this work to adopt a rigid system of transliteration in reference to native names, giving as alternatives some of the popular forms of writing them. This might easily have been done as regards names of Hindustani origin; but as a large number of those which are mentioned are derived from other languages, and as in many cases doubts arose as to what the real spelling should be, owing to their being written in so many different ways by different authors, it was found impracticable to arrive at any uniformity. Accents have been altogether omitted, as it is now pretty evident that their use will not be generally adopted in spite of the very strong reasons which exist why they should. In order, however, to make up for this deficiency in the text, and to convey the true form of pronunciation as far as possible, accents have been used in the index.

In conclusion the author can only say that though many weary hours have been spent in the preparation of this large volume, it has been to him a labour of love, and a labour for which he has for several years made preparation, in the belief that it would one day fall to his lot to undertake the task; he trusts therefore that it will be found to fill the gap which was on all sides admitted to exist in reference to the available information on this important subject.

While his thanks are due to several of his colleagues for the information which they have afforded to him, upon subjects regarding which they possess special knowledge, to the Superintendent of the Survey, Mr. H. B. Medlicott, F.R.S., he owes a no ordinary amount of gratitude for the unwearied liberality with which his advice and aid have been given throughout the work.

ERRATA ET CORRIGENDA.

Page 3	line	7, and page 5 line 29, *for* Akbar *read* Akbari.
„ 46	„	13 from bottom, *for* Bildars *read* Beldars.
„ 54	„	3, *for* Rajputana *read* Punjab.
„ 72		bottom line, *for* are *read* is.
„ 78	„	9 from bottom, *for* Sahaoori *read* Sahajori.
„ 113	„	1 in table, *for* Hygrosopic *read* Hygroscopic.
„ „	„	8 from bottom, *for* Halstead *read* Halsted.
„ 115	„	8, Full stop after "Tenasserim."
„ 153	„	8 from bottom, *for* C_{18} *read* C_{14}.
„ 219	„	18, *insert* as *after* since.
„ 311	„	3, *for* Malabar and *read* Maulmain and other localities in.

MANUAL OF THE GEOLOGY OF INDIA

PART III: ECONOMIC GEOLOGY.

CHAPTER I.

DIAMOND—GRAPHITE—AMBER.

DIAMOND—General remarks. *Madras*—Kadapah (Cuddapah); Bellary; Karnul; Kistna and Godavari (Golconda); Bhadrachellum. *Bengal*—Chutia Nagpur; *Central Provinces;* Bundelkhand (Panna). GRAPHITE—General remarks. *Madras*—Travancore; Tinnevelly; Kistna and Godavari; Vizagapatam. *Bengal*—Lohardaga; Sambalpur; Rajputana. *Extra-Peninsular*—Afghanistan; North-West Provinces; Darjiling; Burma. AMBER—General remarks; Burma.

Diamond: General Remarks.—However interesting it might prove, it would scarcely be appropriate to the present work to attempt a *résumé* of the early records which exist as to the esteem in which the diamond has been held by the nations of antiquity.[1] The name *Adamas*, by which it was known to the Greeks and Romans, was derived according to some authorities from the Arabic *Mas* or *Al' mas;* but according to others, this name was not at first applied to the diamond. Besides indirect proof that the east was the source from whence the diamond originally came to Europe, definite references to India, and in India to the eastern coastal regions, make their appearance in the works of the Greeks and Romans; but it is in Sanscrit literature, and naturally so, that the first mention of the actual localities is to be found.

Although it is probably not true that the stone now known as the Koh-i-nur belonged to Karna, the King of Anga, about 5,000 years ago, and afterwards to King Vikramaditya of Oujein (56 B.C.) as has sometimes been asserted, it is none the less certain that very ancient Sanscrit works treat of the diamond with considerable detail. In a recently published work by Raja Sourindro Mohun Tagore,[2] will be found an account, in four languages, of the precious stones of India,

[1] Reference may be made for discussion of this subject to Karl Ritter's 'Erdkunde Asien,' Vol. VI, p. 343, and C. W. King's "Precious Stones, Gems and Precious Metals;" Bell and Daldy, London, 1865, p. 22.

[2] *Mani Mala,* or a Treatise on Gems: Calcutta, 1879.

as described in the 'Puranas' and other classic works of the Hindus. The accounts of the actual mines given in this work, derived from various modern authorities, are not very accurate, and certainly not up to date; but the work contains much that is interesting concerning the esteem in which precious stones have been held from the earliest times, together with details of the respective properties attributed to them. For our present purpose it will be sufficient to quote the list of localities where the diamond was said to occur, with the supposed modern equivalents :—

1. Haima (Himalayas).
2. Matanga (Kistna and Godavari or Golconda).
3. Surashtra (Surat).
4. Paunda (probably included the Chutia Nagpur localities).
5. Kalinga (countries between Orissa and the Godavari).
6. Kosala (the modern Ajodhya or Berar).
7. Vena Ganga (the Weinganga).
8. Saubira (the tract between the Sarhind and Indus rivers).

From what work this list was taken is not stated, but a similar one is to be found in the Brhat Sanhita [1] which is believed to have been written in the middle of the sixth century. The mention of *Haima*, the diamonds from whence are said to have been copper-coloured, may be spurious, but is interesting in connection with a reported discovery of diamonds near Simla, to which allusion will be made on a future page. The second locality, Matanga, subsequently known as Telingana, included the Kistna and Godavari or Golconda localities, and possibly also some of those situated in districts further south. Marco Polo referred to the same region under the name Mutfili after a port called Motupalle.[2] The third locality, Surat, was probably merely a mart whence the stones were shipped to the west; they are said to have been copper-coloured also. From the testimony of many writers it is known that the stones which were exported were generally inferior to those which were kept in the country for the use of Rajas and Nawabs, but possibly the Surat stones were not really diamonds, but carnelians. The English travellers Fitch and Newbury speak of Belgaum as being a mart for diamonds in the year 1583.[3]

Paunda, the fourth locality, possibly included Sambalpur as well as certain localities in Chutia Nagpur. If not, Sambalpur was either included in Kalinga which appears to have embraced the mouths of the

[1] Translated from Sanscrit into English by Dr. H. Kern, Jour., Roy. As. Soc., Vol. VII, new series, 1875, p. 125.

[2] Colonel Yule's 'Marco Polo,' Vol. II, p. 295.

[3] Selections from Records, Bombay Government, VIII, p. 7.

Mahanadi, and the marts on the coast to which the diamonds were probably brought for sale, or, possibly, it was in Saubira. Ptolomey's account of this region will be alluded to on a future page. Kosala is identified by some authorities with Berar, by others with Ajudhya; it is impossible to say what place may be referred to, perhaps Panna, which, according to some writers, was the Panassa of Ptolomey. The seventh locality, Vena Ganga, is doubtless the Beiragurh of the "Ain-i-Akbar," the modern Wairagarh, which is on a tributary of the Weinganga. The eighth locality, Saubira, if it was in the tract between the Sarhind and Indus, cannot be identified with any known source of diamonds.

There is one point in reference to the discovery of diamonds about which much might be written, and that is the ethnology of the miners. In the majority of cases they belong to the aboriginal tribes, and were probably chiefly of the Dravidian family, the trade being hereditary. There is nothing to connect the earliest workings distinctly with Aryan influence, in fact the Sambalpur localities were in the country of the Sabaræ or Savaras, which may perhaps have been the Saubira of the above list. The Panna mines formerly were and still are worked chiefly by Gonds or Kols, and the miners in Southern India, though some of them are said to be Hindus and others are simply described as low outcastes, all probably came from the same family. It may of course be said in answer to this that the mining and washing would naturally fall to the lot of Helot races, but in some of the localities it is doubtful whether the Aryans ever held paramount power.

On a future page the mythical system of diamond-seeking described in the travels of Sindbad and Marco Polo and in other works will be alluded to, and an origin of the fable suggested.

It would be useless to attempt to indicate the relative periods of the discoveries of diamonds at these several localities. Tavernier is certainly an untrustworthy guide, since, although he states that those at Soumelpour were the oldest in India, it is certain that in his time there were mines existing of which he knew nothing. It seems not improbable that the mines of Panna may be the most recent, but this is doubtful.

It has sometimes been stated that Tavernier first made the Indian diamond famous in Europe; this is calculated to mislead, as not only does he himself allude to an already existing trade, but Marco Polo and Fitch and Newbury also speak of it. Karl Ritter suggests, though he admits that there is some doubt about it, that the trade to the west dates back to the older Arabic and Phœnician times further up to the Solomanic and even to the Egyptian in the Mosaic period.

Before the year 1728, when the first diamond mines in Brazil were opened up, nearly the whole supply of the world went from India, as according to Tavernier, the ruling monarchs would not permit of the export of any stones from Borneo, which was then the only other diamond-producing country.

Passing from more or less vague speculations to actual facts, the geographical distribution of the localities where diamonds have been found first claims consideration. There are in India three extensive tracts, widely separated from one another, in which the diamond is known to occur. Besides these principal tracts there are others, where, although the fact of the occurrence of diamonds has been recorded, information in reference to the circumstances connected therewith is less perfect. But with regard to the three principal tracts it may now be fairly claimed that our knowledge of the geology of India enables us to fix the limits with approximate accuracy, within which the diamond-bearing strata occur, and outside of which it would be useless to look for them. Moreover, we may venture perhaps to extend within those limits, very considerably, the areas in which it may reasonably be anticipated that the gem could be sought for successfully.

The most southern of these tracts, or part of it, has long borne a familiar name, which, however, must be characterised as being to a certain extent a misnomer. Golconda (*Kala-Kandar*), itself, never produced diamonds; it was in fact merely the mart where they were bought and sold. The name originally applied to the capital, now represented by a deserted fort in the neighbourhood of Hyderabad, was extended to the surrounding district, and seems to have been used for a time for the whole kingdom,[1] which was previously called Telingana and included many of the diamond localities. In this way the popular belief on the subject arose; but Golconda fort, it should be remembered, is many miles distant from the nearest of these. At the present day there is a totally distinct tract of hilly country lying to the north of the Godavari river, which also bears the name Golconda, and formed a portion of the ancient kingdom, but it is not now included in the territories of the Nizam of Hyderabad.

The districts included in this southern tract in the Madras Presidency, in which there are or have been diamond mines, are the following: Kadapah or Cuddapah, Bellary, Karnul, Kistna and Godavari.

[1] "Golconda is the most famous of the six independent Moslem kingdoms which in A.D. 1399 rose on the extinction of the Toghlak (Delhi) dynasty, and it survived till 1688, when Aurungzeb brought all India under one sceptre."—*Captain Burton, Quar. Jour. of Science, Vol. VI, New Series.*

Proceeding northwards the next locality at which mines or washings for diamonds are said to have been situated was at Bhadrachellum, on the Godavari.

At Bachimalli, in the Southern Mahratta country, Mr. Foote[1] observed a pebble bed at the base of the Bhima series, which presented a strong resemblance to some of the diamond-bearing strata of the lower Kistna Valley. There were numerous excavations, but he could not learn of any local tradition attributing these to diamond-seekers. Although it has sometimes been supposed that one of Tavernier's diamond mines, Raolconda, was in this region, his indications of its position on being analysed do not support this view.

Still further north we come upon the second great tract which occupies a considerable area between the Mahanadi and Godavari rivers. Although diamonds are known but from two neighbourhoods within it, still from our present knowledge of their geology, to which allusion will presently be made, it is not improbable that the diamond-bearing strata may have a wide range. The two neighbourhoods referred to are Sambalpur, with the bed of the Mahanadi for many miles above it, and Wairagarh or Weiragud, 80 miles to the south-east of Nagpur.

Again, as an outlier to this second tract, there are two or three localities within the province of Chutia Nagpur, where diamonds have been found.

The third great tract is situated in Bundelkhand, near one of the chief towns in which, Panna, some of the principal mines are situated; but there are others scattered about in various parts of that province or kingdom.

Some authorities make allusion to a discovery of diamonds in the bed of the Ganges; but this statement appears to be unfounded. In the Burdwan Division the old Madaran Sirkar included a village called Hirpah, where, according to the late Mr. Blochmann, the "Ain-i-Akbar" states that there was a diamond mine which produced small diamonds. This too is probably due to some mistake. It is not at all likely that real diamonds were ever found there.

Lastly, about ten years ago, some small diamonds, stated to have been found in a hill stream near Simla, were forwarded by Sir E. C. Bayley to the Geological Museum at Calcutta.

Although in the following pages a sketch of the mode of occurrence of the diamonds at each locality will be found, it will be well perhaps, by way of introduction, to give a general account of the formations

[1] Mem., G. S. I., Vol. XII, p. 144.

which include the diamond-bearing beds, and likewise attempt to correlate those of the several localities respectively.

In Part I the subject has already been discussed at length, so it is unnecessary to do more than state the latest conclusions as to the relations of the formations in which the diamonds occur. The Vindhyan rocks of Northern India are separated into two formations or sets of groups, distinguished as upper and lower. In Southern India, and possibly also in the Central Mahanadi-Godavari tract, it is believed that the lower set of groups is alone represented; on the southern rocks the local title of Karnul formation has been conferred, and the two have been correlated as follows:—

	Northern India. *Vindhyan Formation.*	Madras. *Karnul Formation.*
Upper.	Bhanrer group	Absent.
	Rewah " (*diamonds*)	
	Kaimur "	
Lower.	Tirhowan limestone	Khundair shales and limestones.
	Palkoa shales	
	Dalchipur sandstones	Paneum quartzites.
	Semri shales and limestone	Jamalmadgu shales and limestone.
	Semri sandstone	Banaganpilly sandstones (*diamonds*).

At Panna, in Bundelkhand, diamonds are only known certainly to occur *in situ* in a conglomerate which is referred to the Rewah group. There are however there, as elsewhere, numerous workings in alluvial or superficial deposits; but the greatest amount of labour is spent in mining in this the bottom bed of the group, which, though it has a wide extension, has only as yet been ascertained to be diamond-bearing in the neighbourhood of Panna town. Although diamonds have not been obtained directly from any lower group, it would appear that this conglomerate is largely made up of pebbles derived from the lowest or Semri sandstone group, and since it is stated by the native miners, according to Mr. Medlicott,[1] that diamonds are sometimes found in these pebbles when broken up, it would seem that the latter must include an earlier if not the original matrix of the gem. This point is of great interest, since it brings us to a horizon, the base of the formation, which is strictly comparable with that of the Banaganpilly group, which includes the lowest known matrix in Southern India.

The order of succession of the rocks in the Mahanadi-Godavari tract has not yet been fully ascertained; but from the fact of the only known localities where the diamond occurs being situated on the margins of the area, it may with a considerable degree of probability be assumed

[1] Part I, page 93.

(notwithstanding possibly faulted boundaries), that the matrix is in a bed close to the base of the formation.

With regard to the minor areas, the Bhadrachellum diamonds, if there be any truth in the story that diamonds were once found there, may perhaps have been derived from some of the Karnul or Vindhyan rocks in the neighbourhood of the Godavari. The geology of the Chutia Nagpur localities is not yet fully known; it is possible that in their vicinity an outlier of the Mahanadi-Godavari representatives of the Vindhyan rocks may exist.

The Simla diamonds, if the find be authentic, are of considerable interest, for although, as has been shown, diamonds *per se* do not afford evidence sufficient for exact correlation, still when it is remembered that according to some authorities the older palæozoic rocks of the Himalayas present certain points of resemblance with those of the Peninsula, the possibility of the matrix containing these diamonds being on a horizon comparable to that in the Banaganpilly group of the Karnul (L. Silurian?) formation cannot fail to suggest itself. As particulars regarding the exact ground whence the diamonds were brought are not available, it would be useless to enter further here into any account of the geology of the neighbourhood of Simla.

Some interesting remarks[1] have recently been published upon the correlation of the Vindhyan rocks of India, with certain series occurring in South Africa, to one of which the sandstones of the Table Mountain belong. The possibility of the original matrix of the Cape diamonds therefore belonging to a period or horizon directly comparable to that which includes the Indian diamonds is a subject worthy of future investigation. It is noteworthy that a rock very similar to Indian laterite appears to occur in the same parts of Africa, and that our Gordwana rocks are also represented in that country. A comparison of the geology of Borneo with that of India may also prove productive of interesting results in this respect.

The examination of the diamond-bearing strata of India has not resulted, so far as is known, in throwing any definite light on the yet unsettled question as to the conditions under which the crystallization of carbon took place, thus forming the precious gem which has occupied so important a position in history. Light regarding the subject seems destined to reach us indeed from another quarter, and it is to the synthetical operations of the laboratory, which, it is needless to point out, have made such great advances in this direction of late years, especially in the hands of Mr. Hannay, that we must look for the true

[1] C. L. Griesbach. Records, G. S. I., Vol. XIII, p. 86.

explanation. The final result of these operations will probably, it is thought, confirm Liebig's view that diamond has been formed by crystallization from a liquid hydro-carbon, the carbon having become concentrated and purified by a steady abstraction of $C. H._4$.

But the absence of any clear evidence on the subject may be due to the fact that it is still a matter of doubt whether in any single recorded case in India a diamond has been found in its original matrix. The lowest diamond-bearing stratum, at the base of the Karnul series, is itself a detrital conglomerate, and it is not unreasonable to suppose that the diamonds may, like the other ingredients, have been derived from some older metamorphosed rocks.

Mr. King[1] discusses some apparent cases of mines in the Kadapah series of rocks which underlies the Karnul series, but he says there is "still a doubt as to whether true rock-workings in these beds were ever successful."

Captain Newbold, when referring to this subject, without much difficulty disposes of Captain Franklin's suggestion that the beds containing the diamonds of Panna may have been roasted by the ignition of coal seams, which he believed underlay the diamond-bearing rocks, but which really have no existence. He then remarks:—"It is fully proved, I think, from the experiments of Sir David Brewster, that the diamond has once been in a soft state, like amber, opal, or the tabashir. Minute cavities, surrounded by a compressed structure, analogous to those in the Laske diamond, are seen in several specimens of the Indian gem which have been brought to me by the diamond merchants." He appears to have been disposed to favour the native idea that the diamond is reproduced in the soil, and says that the old miners told him that a term of fifteen or twenty years was requisite for the reproduction of the gem. They were in this belief led to rewash old tailings, and accounted for the fact of the diamonds found in them being so small by saying that they had not had time to grow larger. An unbeliever in this hypothesis would be inclined to suggest that the smallness of the diamonds accounted for their having eluded the searchers in the first washings. The same story is alluded to by many of the other writers whose descriptions are quoted in this account. Some of them appear to have thought, with Newbold, that there was something in it, while others pointed out that diamonds in all probability escape the first examination in consequence of an encrustation which subsequently being broken up and decomposed by exposure to the atmosphere, the gem became visible in the later washings.

[1] Mem., G. S. I., Vol. VIII, p. 88.

Madras: Kadapah (or Cuddapah) District.—Within the limits of the Kadapah district the principal localities where diamonds have been worked for are, according to Mr. King, Cunnapurtee and Woblapully (or Obalumpally) near Chennur, but on opposite banks of the Pennair river, and Lamdur and Pinchetgapadu west of Chennur. The District Manual mentions also Goulagoonta or Jamalamdugu, Goorapur and Hussanapur or Doopaud. With reference to the last named, proposals were made in 1804 by Colonel Munro to increase the number of mines in twelve months to thirty; all diamonds of more than a pagoda in weight (=16 carats according to Heyne) were to become the property of Government; 2½ per cent. of the value of all smaller ones was also to be paid. The expense of working the mines, it was calculated, would be Rs. 24,030 annually. It is stated that thirty years previously the miners paid Rs. 50,000 annually to the Government.

In an account of his visit to Gandicota Tavernier mentions that the Nawab had employed 12,000 men, for a year, to search for diamonds in this neighbourhood, but all that were found were of such bad quality that the mines were abandoned. These mines collectively are generally referred to under the title of

CHENNUR OR CHINON, Lat. 14° 34′; Long. 78° 51′ 30″. This is a village near Kadapah town, where there are deserted pits, which were sunk in gravels, derived from the disintegration of the Banaganpilly quartzites, and lying below the black cotton soil or *regar*. The mines were leased for a time by a Mr. Richardson, of Madras, who applied to the Collector of Kadapah for permission to work them in 1869, at the favourable rent of Rs. 100 per annum. This attempt has not been attended with success,[1] but there are accounts of two diamonds having formerly come out of this field which were eventually sold, respectively, for £5,000 and £3,000.[2]

CUNNAPURTEE appears to be identical with the Condapetta of Dr. Heyne and Captain Newbold; the detailed account by the latter is perhaps of sufficient interest to be quoted *in extenso*. He says[3]:—

"At Condapetta the mines are generally of a square form, and from 4 to 12 feet deep. The stratum cut through is of cotton soil, mixed with small grains of quartz, generally from 3 to 10 feet thick, which rests immediately on a bed of rolled stones of various sizes, from that of a paving stone to a nut, in which the diamonds are found, generally loose, but sometimes adherent. The stones are mingled with

[1] *Vide* Cuddapah District Manual, p. 25.
[2] King, Records, G. S. I., Vol. II, p. 9; and Mem., G. S. I., Vol. VIII, p. 266.
[3] Jour., Roy. As. Soc., Vol. VII, p. 226.

mud and gravel. The pebbles most commonly met with are ferruginous, gritty, and schistose sandstones, sandstone-conglomerates including rolled pebbles of quartz, chert and jasper, claystone porphyry, with crystals of felspar; blue jasper, veined with oxide of iron; coarse, red jasper and quartz crystals. Some of these pebbles have evidently been transported from the adjacent hills, but the porphyritic and felspathic pebbles must have travelled a much greater distance. Near the base of the hills the cotton soil is covered with the red gritty earth, arising from the disintegration of the sandstone rock.

"The process of mining consists merely in digging out the rolled pebbles and gravel, and carrying them to small square reservoirs raised on mounds having their bottoms paved with stones, and washing them carefully. At the foot of the mound is a clear space surrounded by heaps of refuse, where the washed gravel is again carefully spread out and examined in presence of the diamond contractors; the diamonds are easily recognized in the moist state by their peculiar lustre. These mines are let out by the Government to native contractors, who gave me the following information on the spot. In 1834, the mines proved profitable, but in the following year the miners lost a considerable sum. The sum paid to Government by them for the privilege of mining a piece of ground 100 yards long by 50 broad, for four months, is Rs. 200. In 1840, the contract rose to about Rs. 250. When a diamond of more than a gold pagoda in weight (=52·56 grains at Madras) is found, it is sold by public auction, and one-third of the proceeds goes to Government, the remainder to the mining contractor.

"Dry weather is selected to carry on operations to avoid the inconvenience and expense of draining. In former days all the diamonds produced were carried for sale to Golconda. In those times very large diamonds were found, but subsequent to British ascendancy—which, according to the superstitious natives, is by no means pleasing to the tutelary deities of the mines—few of any value have been found, probably in consequence of their being less looked after. However, lately, in 1839, a fine diamond of the Kshatriya or roseate caste was dug from the Obalumpally mine, exceeding a gold pagoda in weight, which was sold for Rs. 1,450."

Both Dr. Heyne and Captain Newbold, when describing their visits to these mines, mention that the natives objected to their approaching them on horseback, as it would, they said, irritate Ammawaru or Lakshmi, the sanguinary goddess of riches, who was the patroness of the

[1] Tracts, p. 95.

mines. Newbold states that he witnessed sacrifices which were made to propitiate her. The different pebbles considered indicative of the presence of diamonds bore the following names in Tellegu: *Tella bendu,* decomposed hornstone; *Binga bendu,* transparent quartz; *Patcha bendu,* epidote; *Gajju bendu,* pebbles with an ochreous encrustation; *Baggira,* jasper of various colours; *Karla,* basalt; *Yerra bendu,* sandstone; *Kanna,* small globular ironstone; *Korund* or Corundum, this is considered to be the best sign. Besides these there are many other pebbles, chiefly varieties of sandstones.

WOBLAPULLY OR OBALUMPALLY, &c., Lat. 14° 34′; Long. 78° 51′ 35.″ Under one of the various aliases by which this place is known, it is referred to by Heyne,[1] Voysey,[2] Newbold,[3] and King.[4] The first mentioned gives the following account of the mines. He says that they were discovered about 40 years before his visit, which took place in the year 1795, and that they were the most recent in this tract. The diamonds which were found were flat or round, not showing the crystalline form, but were of superior lustre and hardness and better than those found further west. A few days after his visit one was found weighing 14 carats, which was valued at 200 Madras pagodas, or about £90.

He gives an elaborate list of the prices at the mines of rough stones free from flaws, &c. A stone of 1 manjely or 2 carats weight, if belonging to the first or Brahmin class, was worth about £9, but if of the Sudra class, only half that sum—the other classes having intermediate values. A stone of 8 manjely, or 16 carats, if of the Brahmin class was worth £180, and if of the Sudra £135. The lessee of ten mines in this neighbourhood, including Condapetta and Obalumpally, paid to the Company 130 pagodas (=£57-4-0). On all stones which were found, weighing above a pagoda or 16 carats, he had to pay to the Company one-third of the value. From the lessee Dr. Heyne understood that an expenditure of 2,000 pagodas yielded 5,000 pagodas, but the business was a lottery in which there were blanks as well as prizes. Lamdur and Pinchetgapadu, localities in the taluk next to Chennur and which were mentioned by Heyne and Newbold,[5] the latter quoting from Hamilton, do not appear on modern maps.

Bellary District.—MUNIMADAGU, Lat. 15° 17′; Long. 78° 2′ 30.″ In the neighbourhood of Munimadagu, 16 miles west by south of Banaganpilly, there is a continuation of the diamond-bearing strata, which cover the older Kadapah rocks as with a thin skin. The locality

[1] Tracts, p. 98.
[2] As. Res., Vol. XV, p. 127.
[3] Jour., Roy. As. Soc., Vol. VII, p. 226.
[4] Mem., G. S. I., Vol. VIII.
[5] Madras Jour. Lit. and Sci., Vol. III, p. 120.

is described both by Mr. King and Captain Newbold.[1] The mines have long been deserted, but according to the last named authority, there was in his time a colony of diamond polishers in the town. He gives diagrams of the apparatus which they used for polishing, and states that they not only employed diamond dust for this purpose, but also understood how to avail of the natural cleavage of the stones. The Bellary District Manual[2] has an interesting account of these mines. Though there is now no systematic mining, diamonds are still occasionally found, but no revenue has been raised on the mines since 1813. The conditions under which they were worked under the Native Governments were—

1. All diamonds weighing one pagoda and upwards to be the property of Government;
2. On others a royalty of two and a half per cent. to be paid to Government;
3. A monthly *nazzar* of one Madras pagoda to be paid for each mine. About the year 1770 half a *lakh*, or £5,000, was paid under this head.

Many Guzerat merchants settled here and their descendants still reside, but the ruins of wells, &c., are the sole testimony to the former wealth and importance of the place. After the district was ceded, 30 mines were in operation, which between the years 1803 and 1833 yielded an annual average revenue of only Rs. 3,600. During this period only seven diamonds weighing more than a pagoda were found, and the leases gradually expired and were not renewed. Mining was a hereditary trade followed only by a class of Balijas called Gunekara. Further information is stated to be given in the documents enumerated below.[3]

WAJRA KARUR, Lat. 15° 2′; Long. 77° 27′ (A. S., 58 & 59). The description of Munimadagu given above from the Bellary Manual appears to be in part applicable to mines at this locality also, as both are mentioned together. Captain Newbold, in 1836, records the bare fact that diamonds were formerly found here.[4]

GUTI OR GUTIDRUG, Lat. 15° 7′; Long. 77° 42′ (A. S., 58). This locality is mentioned by Heyne[5] as having mines near it; possibly he referred to Munimadagu and Wajra Karur, as it lies between them; no other authority alludes to it.

[1] Jour., Roy. As. Soc., Vol. VII, p. 230; and Madras Jour. Lit. and Sci., Vol. XI, p. 48.

[2] Madras, 1872.

[3] Letter from Colonel Munro to the Board, 24th July 1804,; No. 748 from Collector to Board, 24th December 1814; and Board's monthly volume for March 1869, p. 1570.

[4] Madras Jour., Lit. and Sci., Vol. III, p. 121.

[5] Heyne's Tracts, p. 94.

Karnul District—Mr. King has given the following list of diamond localities in the Karnul District:[1]

Banaganpilly .	37 miles S.S.E. of Karnul. Rock workings worked. Lat. 15° 18', 30"; Long. 78° 16' (A. S., 76).
Ramulkota .	18 miles W. by S. of Karnul. Alluvial washings worked. Rock workings deserted. Lat. 15° 34'; Long. 78° 3' 15" (A. S., 58).
Timapooram .	6 miles E. S. E of Ramulkota. Rock workings deserted. Lat. 15° 32' 30"; Long. 78° 6' 30" (A. S., 58).
Yembye . Byanpully . Gooramanconda .	24 miles; S.S.E. of Karnul. Rock workings deserted. (Captain J. G. Russell *teste.*) Lat. 15° 32'; Long. 78° 14' 15" (A. S., 76).
Goodypaud . Bannoor . Devanoor .	Nundycotkoor taluq. Doubtful localities. (Captain J. G. Russell, *teste.*)
Shaitancotah .	Right bank of Toongabudra, E.N.E. of Karnul. Deserted.
Deomurrooh .	Left bank of Toongabudra. Deserted. Lat. 15° 49'; Long. 78° 11' (A. S., 76.).
Tandrapad .	Left bank of Toongabudra. Alluvial deserted. Lat. 58° 51'; Long. 78° 7' (A. S., 58).
Buswapoor .	Nullamullays. Rock workings and alluvial washings deserted. Lat. 15° 25'; Long. 78° 43' 30" (A. S., 76).

BANAGANPILLY, Lat. 15° 18' 30"; Long. 78° 16' (A. S., 76). The diamond mines at this locality have been visited and described by many writers. Heyne,[2] Newbold,[3] Malcolmson,[4] and Voysey[5] have all left on record accounts of them.

Mr. King's already mentioned report contains the latest and most authentic account of them. It will be best perhaps to quote from it a few passages *verbatim,* at the same time stating that Mr. King refers those who are likely to be specially interested to Dr. Heyne for an account of the mines as they appeared when he saw them in the year 1808.

Mr. King writes:—

"The quartzites of the Banaganpilly group form a cap, resting unconformably on the denuded surface of a much older set of shales and traps with some limestone bands . . . The quartzite covering is from 20 to 30 feet in thickness, and it is pierced here and there over the Banaganpilly end of the hill by shafts of 15 feet or less, from the bottoms of which nearly horizontal galleries are run to get at the seams of diamond gangue. The capping is composed of compact grits and

[1] Mem., G. S. I., Vol. VII, p. 106.
[2] Tracts, p. 102.
[3] Madras Jour. of Lit. and Sci., Vol. III, p. 120.
[4] Trans., Geol. Soc., Lond., 2nd series, Vol. V. pp. 511 and 568.
[5] As. Res., Vol. XV, p. 124.

sandstones in thickish beds above, and somewhat thinner bedded towards the bottom.

"Externally the rocks are hard and vitreous. At the level of the galleries there are *beds of coarse pebbly conglomerate, occasionally a breccia,* which are sandy and clayey, and with these run seams of more shaly and clayey stuff. There is no trace of the clayey constitution on the outside along the outcrop, nor are there any distinct bands of shales; there are only some sandy shales down at, or near, the bottom of the series.

". . . In the mines the coolies were picking out a seam of about 6 or 8 inches in thickness, occurring with thicker and harder beds of sandstone, and which they said was the diamond layer; this rock when brought to light turned out to be an easily broken-up damp, clayey conglomerate, and partly brecciated, of small rounded fragments and pebbles of black, red, green, and pale-coloured shales and cherts, and of quartzite with large and small grains of dirty and pellucid quartz. This was the rock extracted in all the mines then being worked. The gangue is pounded up, washed, sifted, and laid out to dry on prepared floors, after which the residue of clean sand is carefully examined in the hand, by the women and children of the working parties, for the precious gems. I saw no diamonds *in situ,* nor did I see or hear of any diamond being found during my stay at Banaganpilly for four or five days at a time. Diamonds were brought to me which were reported to have been found in the mines; but these were most disappointing on account of their minuteness, flaws, and dirty colours."

Large stones do not appear to have been found here: Captain Newbold says none of a value exceeding from Rs. 300 to 400. Mr. King saw one valued at Rs. 350, but which was said to have come from the Bellary district. Among the specimens which he saw, and which had regularly crystalline forms, the most valuable was only worth Rs. 10. He was able to trace the extension of the diamond-bearing stratum for several miles to the west beyond the region wherein it is worked.

The diamond mines of Buswapur are briefly described by Captain Newbold in a paper published in the Journal of the Asiatic Society;[1] but as they were then deserted and overgrown with thick jungle, his account need not be reproduced. The same remark applies to all the other localities which are included in the above list, except Ramulkota.

Ramulkota, Lat. 15° 34′; Long. 78° 3′ 15″ (A. S., 58). The mines near Ramulkota are situated about 19 or 20 miles south-south-west of Karnul; they were excavated in the quartzites of the Banaganpilly

[1] Vol. XV, 1846, p. 390.

group.[1] When visited by Captain Newbold about the year 1840[2] only 20 men were at work, but during the dry season 500 were employed. In the wet season operations were wholly suspended owing to the pits becoming full of water. The contractors held the mines from the Nawab for an annual payment of Rs. 750, and sublet them to the parties of operatives. The mines, though not spread over so large an area as those near Chennur, were deeper and more extensive.

The diamonds seen by Captain Newbold were of small size and not of regular crystalline form; they were of white, grey, yellow, and greenish tints. The processes of mining and washing were similar to those practised at Banaganpilly. Labourers received only four pice, or about three halfpence, and a meal of rice *per diem.*

Mr. King states that there is no rock-mining carried on at present, but alluvial washing is practised, the material being dug from the edge of the alluvial plain close to the village. The northern base of the Gunnygall range is covered with the deserted ruins of pits and heaps of broken stones.

Raolconda.—The identity of Raolconda which was visited and described by Tavernier about the year 1665 has long given rise to much speculation. The map of Jefferys published in 1768, and that of Rennell published in 1788, do insert Raolconda in the angle between the Bhima and Kistna rivers, and the exact stages to it mentioned by Tavernier; but it is quite certain from the other localities also given that these routes were taken from Tavernier, and not from an independent source. Rennell indeed says so in his memoir. A much more trustworthy map is one by Colonel Colin Mackenzie, dated 1798, which was largely founded on actual surveys, and the original manuscript of which is now in the Surveyor General's Office, Calcutta; in this Raolconda does not appear.

The writer of this was recently led[3] to suggest that Raolconda might be identical with Rawdukonda, as it seemed to fit best with the distances given by Tavernier; but the hypotheses depended on the value to be given to his 'league,' which in this calculation was assumed to be equal to $4,444\frac{1}{2}$ metres, and therefore, the *gos* of Tavernier which contained four of these, was supposed to be equal to 11·12 miles. But as an alternative Ramulkota was suggested. Mr. King (*in epist.*) has since clearly shown, by identifying Tavernier's stages, that Raolconda must have been at or close to Ramulkota. A necessary consequence of this is that Tavernier's league cannot have exceeded 2 miles, and the *gos* was therefore equal to 8.

[1] King, W. Mem., G. S. I., Vol. VIII, p. 105.
[2] Madras Jour. of Lit. and Sci., Vol. XI, p. 47; and Jour., Roy. As. Soc., Vol. VII, p. 231.
[3] Jour., As. Soc., Bengal, Vol. L, 1881, p. 36.

Tavernier's description of the mines at Raolconda, which are in all probability represented by the old workings now to be seen near Ramulkota, is as follows:—

"The strata containing the diamonds ranged from half an inch to an inch in thickness, and the gangue was hooked out with iron rods. Some of the stones were valued at from two to sixteen thousand crowns. The steel wheel was used for cutting."

Tavernier gives an account of the polishing of the gems as practised there. His account of the great security of property, and system with reference to the sale of diamonds, together with the courtesy with which he was treated, will be read generally with interest.

Kistna and Godavari (Golconda) Districts.—Proceeding down the valley of the Kistna or Krishna river from west to east, the localities where diamonds have been worked for are as follows: Kollur (the *Gani Coulour* of Tavernier), Wustapilly or Oostapully, Codavetty-Kallu, Atkur, Barthenypadu, Partial, or Gani Partial, Mulely or Mullavilly and Golapilly.

Further west, indeed at Damarapad and Malawarm, lat. 16° 35′ 3″; long. 79° 30′, deserted mines exist, but there are no published particulars regarding them, unless they were the mines referred to by Tavernier as being situated beteen Coulour and Raolconda, and which were closed by order of the king on account of the brittle character of the diamonds found there.

KOLLUR, Lat. 16° 42′ 30″; Long. 80° 5′ (A. S., 75). The identity of the modern Kollur with the Gani Coulour of Tavernier, which is written simply Gani by many English authors, has recently been discussed by the writer.[1]

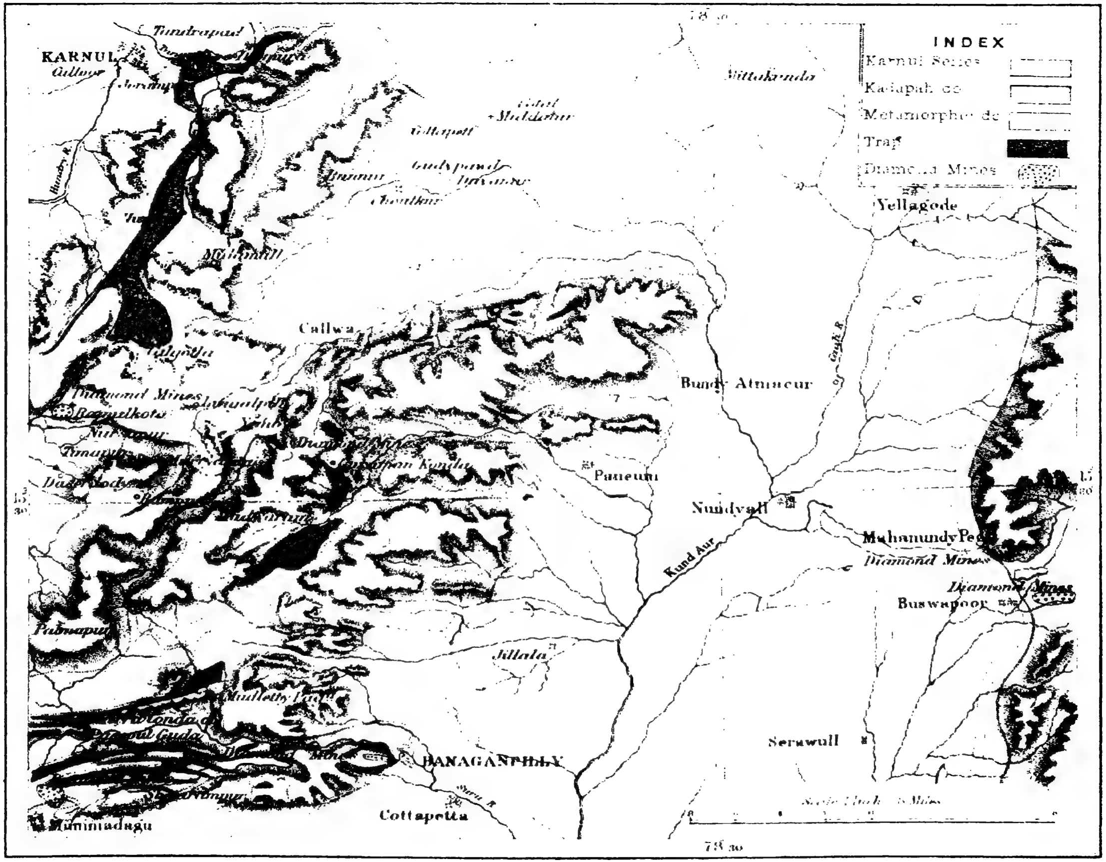
It is thought that perhaps it will not be considered unsuitable to reproduce this note, as so much interest naturally attaches to the history of the Koh-i-nur, which, it is believed, was found there. There being no space available in this volume for complete histories of all the famous gems, the reader is referred to any of the numerous works on precious stones for the well-known facts regarding the Koh-i-nur during the two centuries before it was taken to England.

The mines at Gani, called also Coulour by the Persians, were situated, according to Tavernier, seven days' journey eastwards from Golconda.[2] In a subsequent chapter[3] to that in which the above statement is made

[1] Jour., As. Soc., Bengal, Vol. L, 1881, pt. 2, p. 34.

[2] Voyages, Liv. II, Chap. XVI, p. 304, Paris, 1677.

[3] *Idem*, Chap. XVIII, p. 316.



Geology by W. King and R. B. Foote

MAP OF THE KARNUL DIAMOND MINES

he adds some details regarding the route, the itinerary being as follows:—

The modern equivalents have been kindly supplied by Mr. King.

Golconda to Almaspinde	. . . .	$3\frac{1}{2}$ Gos. (? $2\frac{1}{2}$)
Almaspinde to Kaper	. . :	2
Kaper to Montecour	. . (?=Moonoogodoo) . . .	$2\frac{1}{2}$
Montecour to Nagelpar	. (=Nagoolpad) . . .	2
Nagelpar to Eligada	. . . .	$1\frac{1}{2}$
Eligada to Sarvaron	. . (=Surrawarram) . . .	1
Sarvaron to Mellaserou	. (=Mailacheroo) . . .	1
Mellaserou to Ponocour	. . . .	$1\frac{1}{2}$
From Ponocour you have only to cross the river to Coulour or Gani.		
	Total .	$14\frac{3}{4}$ Gos.

The total of these items amounts to $14\frac{3}{4}$ *gos*, and in the English edition of the Travels[1] amounts to $15\frac{3}{4}$. But it must be concluded that both tables contain misprints, since Tavernier expressly says that the distance was $13\frac{3}{4}$ *gos*, or 55 French leagues, the *gos* being equal to 4 leagues. Taking this league to be equal to $4{,}444\frac{1}{2}$ metres, its value expressed in English miles would be 2·78, and therefore the *gos* ($2{\cdot}78 \times 4$) would be equal to 11·12 English miles, or rather less than the modern Indian stage distance of six *coss*, or about 12 miles. From other considerations, however, it seems that this is too high a value for the league; as Tavernier used it, it was in fact only about 2 miles and the *gos* equalled therefore 8 miles and is doubtless the same as the *gow* of Heyne.[2] The distance of Coulour from Golconda was therefore, by the route taken by Tavernier, 110 miles.

On the south bank of the Kistna west of Chintapilly, in lat. 16° 42′ 30″ north, and long. 80° 5′ east, there is a diamond locality, which on an old engraved map, that by Thomas Jefferys (London, 1768), is called Kalur or Gani. This, it may be thought, would finally settle the question; but as has been said in reference to Raolconda, both this authority and Rennell evidently took their information from Tavernier, and not from independent sources.

Fortunately a manuscript map by Colonel Colin Mackenzie, of the Nizam's dominions, which is dated 1798, indicates this locality as Coulour

[1] Lond., 1684, Part II, Book II, p. 142.

[2] Heyne (Tracts, p. 94) mentions the *gow* as a term in use in his time (1795). It was, he says, equal to 8 miles.

and marks it as a diamond mine. Partial is written *separately* in its proper place as Gani-Purtial, and so also is a well-known intermediate locality at Istapully, and both are marked as having diamond mines. Still further, a route given by Tavernier between Golconda and Masulipatam *viâ* Coulour completely confirms this view. On the whole we are bound to conclude therefore that Tavernier's Gani Coulour was not identical with Gani Purtial, the modern Partial, but with the modern Kollur as it is written on the atlas sheet, No. 75. So far as can be gathered from that map, its surroundings are not inconsistent with Tavernier's description. He says the mine is close to a large town on the same river, *i.e.*, the Kistna, which he crossed on the road to Raolconda, and that a league and a half from the town there are high mountains which are in the form of a cross. In the intervening plain the search for diamonds was carried on. The locality too, it may be added, is in the middle of presumably diamond-bearing rocks.

Now, as regards this word Gani there is still a remark to be made. Its recurrence in the titles of two mines, which have been shown to be distinct, suggests that it was not a proper name, and that in fact it really meant 'mine of' being only a corruption of *Kan-i*.[1] We know that the letters g and k are interchangeable in some Indian languages, and therefore no particular effort is required to accept the view that Gani Coulour meant simply the mine of Coulour, *i.e.*, the modern Kollur; so that to speak of the mine of Gani as is often done is meaningless tautology.

The following account by Tavernier[2] shows the former extent of diamond-mining operations at this locality:—

"It is not above a hundred years since this mine was discovered by a countryman, who digging in a piece of ground to sow millet found therein a pointed stone that weighed above twenty-five carats. He, not knowing what the stone was, but seeing it glisten, carried it to Golconda, where, as it happened well for him, he met with one that traded in diamonds. The merchant, informing himself of the place where the stone was found, admired to see a jewel of that bigness, not having seen before one that weighed above ten or twelve carats. However, his report made a great noise in the country, insomuch that the moneyed men in the town set themselves to work, and causing the ground to be searched they found and still do find bigger stones and in greater quantity than in any other mine, for they found a great number of stones from ten to

[1] *Vide* 'Punjab Manufactures,' p. 197.
[2] Travels, English Edition, 1684, Part II, Book II, p. 137.

forty carats, and sometimes bigger, among the rest that large stone that weighed 900 carats, which Mirimgola presented to Aurengzeb.

"The first time I was at the mine there were about 60,000 persons at work—men, women, and children, the men being employed to dig, the women and children to carry the earth.

"After the miners have pitched upon the place where they intend to work, they level another place close by, of the same extent, or else a little bigger, which they enclose with a wall about 2 feet high. In the bottom of that little wall, at the distance of every 2 feet, they make small holes to let in the water, which they stop up afterwards till they come to drain out the water again. The place being prepared the people that are to work meet all together, men, women, and children, with the workmaster in the company of his friends and relations. Then he brings along with him some little image of the god that they adore."

After describing the worship of this and a feast of rice, he continues :—

"When the feast is over the men fall to digging, the women and children to carry earth to the place prepared in the manner I have already described. They dig 10, 12, and sometimes 14 feet deep, but when they come to any water they leave off.

"All the earth being carried into the place before mentioned, the men, women, and children throw the water which is in the drains upon the earth, letting it soak for two or three days according to the hardness of it, till it comes to be a kind of batter, then they open the holes in the wall to let out the water and throw on more water still till all the mud be washed away and nothing left but the sand, after that they dry it in the sun, then they winnow the sand in little winnows as we winnow our corn.

". . . The earth being thus winnowed, they spread it with a kind of rake, as thin as they possibly can; then with a wooden instrument, like a paviour's rammer, about half a foot wide at the bottom, they pound the earth from one end to the other two or three times over. After that they winnow it again and then, spreading it at one end of the van for fear of losing any of the earth, they look for the diamonds. Formerly they were wont to pound the earth with great flintstones instead of wooden rammers, which made great flaws in the diamonds, and is, therefore, now left off."

Identity of the Great Mogul Diamond with the Koh-i-nur.

As the identity of the Great Mogul or Kollur diamond has been the subject of much controversy, the following note is inserted here since it properly comes under the head of Gani-Coulour or Kollur. Tavernier

states that not only it but many other large stones were produced there, and he adds that in his time the miners still continued to find large stones in the same mines.

Tavernier having gone to take leave of the Great Mogul (Aurengzeb) on the 1st of November 1665, was invited to return on the following morning to see the Emperor's jewels. He says: [1] "The first object which Akel Khan (the custodian of the jewels) put in my hands was the great diamond, which is a rose, round, very convex (*haute*) on one side; at the edge of one side there is a small notch (*cran*) with a flaw in it. The water is perfection and it weighs 319½ *ratis*, which are equal to 280 of our carats, the *rati* being seven-eighths of a carat. When Mirimgola, who betrayed the king of Golconda, his master, made a gift of this stone to Sháh Jahán, from whom it is descended, it was uncut and weighed 900 *ratis*, which are equal to 787½ carats, and it had many flaws. If this stone had been in Europe it would have been differently treated, for some good pieces would have been taken from it and the stone left much larger; as it is, it has been almost polished away. It was *Sieur* Hortensio Borgio, a Venetian, who cut it, for which he was badly paid. They reproached him with having spoilt the stone, which ought to have remained heavier, and instead of paying him, the Emperor made him pay a fine of Rs. 10,000, [2] and would have taken still more if he had possessed it. If Hortensio had known his work better he might have taken some good pieces off without doing injury to the king, and without having expended so much trouble in polishing it, but he was not a very accomplished diamond-cutter."

It is believed by some authorities that very large pieces, namely, the Orloff diamond and a stone now in Persia, were as a matter of fact cleaved off from the original Great Mogul. Certainly cleavage had as much to do with the shape of the Koh-i-nur as polishing.

In the chapter on his visit to the mines at Coulour,[3] he says, as quoted above, that the Great Mogul diamond was found there. If this be true, and also that the mine was only discovered about 100 years before his visit, which took place between the years 1665 and 1669, then this diamond cannot have the great antiquity claimed for it by some writers, as has been alluded to on page 1.

Tavernier's third mention of it, which is accompanied by a figure, is as follows: "This diamond belongs to the Great Mogul who did me the honour to show it to me with all his other jewels; one sees the form

[1] Voyages, Vol. II, Livre, 2, p. 249. Paris Ed. 1677.

[2] Even this item is variously stated by compilers who seem to have been the cause of much of the confusion that exists about the weights, &c., of this historical gem.

[3] *L. c.*, p. 305.

which it received on being cut. On my being permitted to weigh it I have found its weight to be 319½ *ratis*, which is $279\frac{9}{16}$ of our carats. In its rough state it weighed, as I have said, 907 *ratis*, which are $793\frac{5}{16}$ carats. The stone has the same form as if one cut an egg in two."

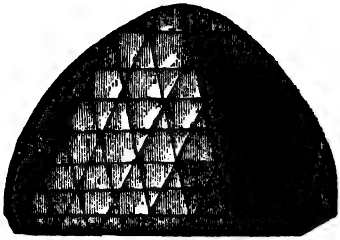
He gives us therefore two different accounts of its weight in the rough, 900 *ratis* or 787½ carats and 907 *ratis* or $793\frac{5}{16}$ carats. It is obvious that there is a mistake, as the two do not agree in any respect; even the equivalent values calculated at 1 *rati* $= \frac{7}{8}$ of a carat should be 787½ and 793⅝. Already strange and unaccountable defects in Tavernier's arithmetic have been pointed out.

Different weights and measures appear to have been used in different parts of the country in his time, the mangelin = 1¾ carats or 7 grains at Raolconda and Coulour; the *rati* $= \frac{7}{8}$ of a carat or 3½ grains at Soumelpour. If we could with approximate accuracy fix the value of the *rati* mentioned by Tavernier, we might succeed perhaps in instituting a fair comparison between the Great Mogul and other diamonds. It seems to be difficult to believe that it equalled 3½ grains, as he states. In Nagpur in the year 1827, according to Mr. Jenkins, the *rati* was only 2·014 grains.

The French grain was equal to about ·77 of a troy grain, therefore since the *rati* contained 3½ of these, its value would have been 2·695, or say 2·7 troy. This fact seems to have been overlooked by some who have endeavoured to reduce the weights given by Tavernier: non-experts too appear to have forgotten that the diamond grain is not identical with any other grain; though our English carat contains four of these grains it only consists of 3·174 troy grains.[1] So calculated, the weight of the Great Mogul would be $\frac{319{\cdot}5 \times 2{\cdot}7}{3{\cdot}174} = 271{\cdot}78$ English carats. If in this equation we could see our way to putting the value of Tavernier's *rati* at 1·848 instead of 2·7, then the exact weight of the Koh-i-nur, when brought to England, or 186·06 carats, would be obtained. The value of the ancient Hindu *rati*, according to Mr. Thomas,[2] was 1·75 grains, from which it gradually increased till in the time of Akbar it was fixed at 1·9375; the mean of these, or 1·843, is nearly equal to the figure required. Supposing, however, that Tavernier's *rati* equalled 2·7 grains as above calculated, the Great Mogul may have been mutilated during its travels, and this may account for the loss in weight, 271·78—186·06 = 85·72 carats, and for the difference in its shape from that of the Koh-i-nur when brought to England. At the same time it is probable that Tavernier's

[1] *Vide* Encyclopædia Britannica, Art. Diamond.
[2] Percy's Metallurgy, Silver and Gold, p. 375.

sketch or diagram, as it might be called, which is here reproduced for



THE GREAT MOGUL.
(*From sketch by Tavernier.*)

THE KOH-I-NUR.
(*Before recutting.*)

comparison, was from memory and was therefore more regular in outline than the original. The name Great Mogul was, of course, not of native origin, but was probably first conferred by Tavernier. By the natives it was in all probability originally known as the Kollur diamond. It has been suggested, if not absolutely stated by some native writers, that the title Koh-i-nur really owes its origin to a change in the originally meaningless name Kollur. Such changes, in which, while the sound is more or less retained, a meaning is acquired, are not by any means rare in Oriental languages, while they sometimes occur in those of Europe. Thus English surnames in the mouths of natives become changed into words of similar sound which have a meaning in Hindustani or whatever the language spoken may be.

From the above it will be admitted that there are good reasons for believing in the identity of the Great Mogul or Kollur diamond of Tavernier with the Koh-i-nur. In spite of the slight differences in weight in his two statements, we cannot suppose that he saw two distinct diamonds, and the hypothesis that the Great Mogul diamond, as it was when seen by Tavernier, still exists in Persia under a different name is wholly without foundation.

WUSTAPILLY OR OOSTAPULLY }
CODAVETTY KALLU } Lat. 16° 40′; Long. 80° 23′ 30″ (A.S. 75).

MOONALOOR OR MOOGALOOR, Lat. 16° 38′; Long. 80° 23′ 20″ (A.S. 75).

ATKUR OR ATANOR AND BARTHENYPADU are close by.

All the above belong to the Partial group, and, so far as they have been mentioned by the different writers, the conditions of occurrence of the diamonds appear to be the same as those which obtain at Partial.

The matrix is a detrital sub-recent bed resting on metamorphic rocks, the materials having been brought down from the adjoining tracts of Karnul rocks, in or on a portion of which the Kollur mines were situated.

Heyne gives the traditional account of the Codavetty Kallu mine, which states that at first bullock-loads of diamonds were discovered.

PARTIAL, Lat. 16° 39′; Long. 80° 27′ (A.S., 75). This locality, which is commonly though erroneously supposed to have enjoyed the honour of having produced the Great Mogul or Koh-i-nur diamond, appears under so many different names that it may be best to mention some of them in order to remove any possible confusion. Ganipartal or Partal (Heyne [1]), Gani Parteala or Parteal (Voysey [2]), Parteal (Walker [3]), &c.

Although it has been disputed it seems not improbable that the Pitt or Regent diamond was found in some one of these mines of the valley of the Kistna. A different account of its origin, given by Captain Newbold, seems to be incorrect. Captain Hamilton in 1727 [4] distinctly refers to it and the circumstances under which it was sold to Mr. Pitt. When visited by Voysey in 1825 the only operations in progress at Partial consisted in researching the rubbish of the mines.

When the Nizam ceded the Northern Circars to the British he was permitted to retain possession of all the village lands of this area in which diamond mines were situated, and these villages now stand isolated in the British Kistna and Godavari districts. The revenue derived from them by the Nizam at present, from ordinary agricultural resources, is not inconsiderable, but the diamond mines yield little or nothing. Eighty years before Heyne's visit, or about the beginning of the 18th century, they belonged to a powerful zemindar called Ooparow, but on his discovering the diamonds, they were taken possession of by his sovereign, the Nizam.

Voysey was of opinion that the diamond-bearing stratum was not nearly exhausted, being intact close to pits whence famous stones had been taken. In 1850 Dr. Walker saw two mines only at work, and these were let for 8 annas each per month. He states that a searcher who makes Rs. 4 or 5 by the sale of the small diamonds deems himself fortunate. As many of the mines were hollowed down to the rock he concluded that the tract was exhausted; but this is scarcely probable, as the stratum in some cases extends under the villages where from superstitious motives it has not been touched.

MULELI OR MALAVILY, Lat. 16° 41′ N.; Long. 80° 56′ E. and GOLAPILLY, Lat. 16° 43′ 30″ N; Long. 80° 57′ E. The mines situated between these two villages may conveniently be treated of together. They are

[1] Tracts, p. 94.

[2] As. Res., Vol. XV, p. 126, and Jour., As. Soc., Bengal, Vol. II, p. 404.

[3] Madras Jour. of Lit. and Sci., Vol. XV, p. 185.

[4] New Account of the East Indies, Vol. I, p. 366.

alluded to by Drs. Heyne, Voysey, and Benza, and Captain Newbold; but within the period to which these records refer they do not appear to have been worked with much result, though Dr. Benza mentions some small diamonds having been found in a particular mine about the year 1830. None of them are worked now.

In reference to Muleli, Mr. King, who has recently written on the subject, says that the old workings are in pebbly sandstones of the Dudugut range, or in superficial deposits consisting of their debris. These sandstones belong to the Golapilly group, and rest partly on lower Gondwana and partly on metamorphic rocks. Mr. King considers it possible that they are in part made up of the debris of Karnul rocks, though none are now exposed in the neighbourhood.

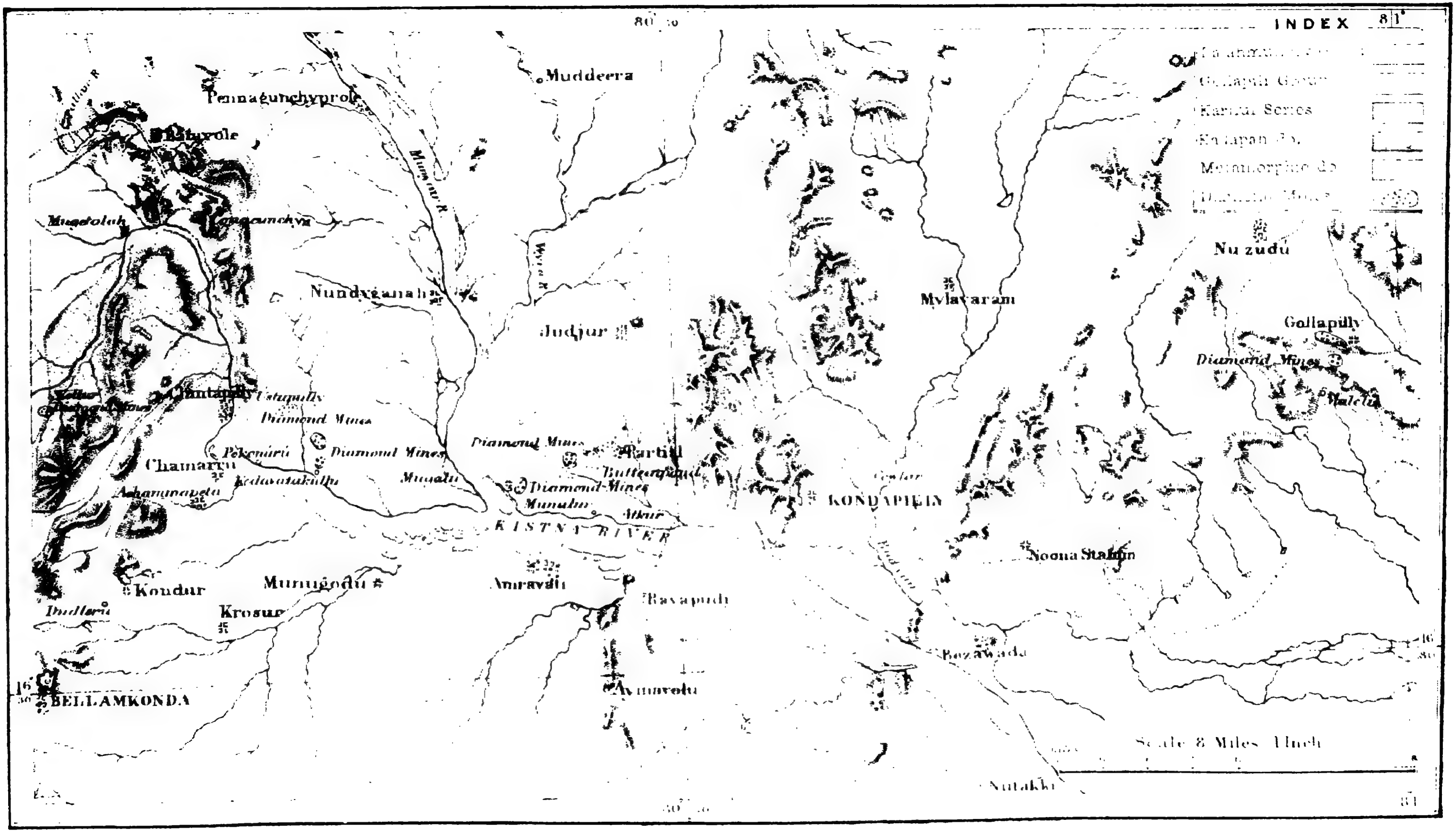
Several of the writers mentioned above allude to the presence of a kunkur bed or calcareous travertin, in association with the diamond-bearing stratum, which, according to Dr. Benza, extended as far as Samulcotah, where it was said diamonds had also been found.

It would be impossible to say now in what particular mines many of the famous diamonds, believed to have come from this so-called Golconda region, were found. Some of them possibly did not come from mines, but were casually found on the surface; thus the Nizam's diamond, which has been described by Mr. Piddington,[2] was about the year 1835 first noticed as a plaything with which a native child was amusing himself. No earlier history of it could be ascertained; its antecedents, therefore, resemble those of the earliest Cape diamond.[3] Very little is known about the weight and quality of this stone. Mr. Piddington, from a leaden model, estimated that in the rough it weighed 277 carats. His account was from information received from Captain Fitzgerald, who was attached to the Nizam's service. A different history of it is given by Captain Burton,[4] who says it was found buried in an earthen pipkin by a sowar at Narkola, 20 miles east of Shamsabad. It is said to have then been broken in three pieces, the largest of which is supposed to weigh 375 carats; but there is a great deal of mystery about this stone.

Bhadrachellum.—This locality on the Godavari is mentioned by both Voysey and Newbold as being one where diamonds were sought for, a not altogether improbable supposition; but no particulars are known.

Bengal: Chutia Nagpur.—The upper portion of Ptolemy's *Adamas flus* passes through a district named Cocconage, which would include Chutia

[1] Mem., G. S. I., Vol. XVI, page 59.
[2] Jour., As. Soc., Bengal, Vol. XVII, p. 152.
[3] Jour., Soc. of Arts, April 1881.
[4] Quarterly Journal of Science, Vol. VI, new series, p. 351.



Geology by W. T. Blanford, W. King, and R. B. Foote

Nagpur. Independently of this, however, there are good reasons for believing that diamonds were found in Chutia Nagpur. The following notices on the subject are from a paper by the late Mr. Blochmann[1] :—

"Kokrah (the ancient name of Chutia Nagpur) was known at the Mogul court for its diamonds, and it is evidently this circumstance which led the generals of Akbar and Jahangiri to invade the district. I have found two notices of Kokrah in the 'Akbarnamah' and one in the 'Tuzuk-i-Jahangiri,' from which it appears that Chutia Nagpur was ruled over in 1585 by Madhu Singh, who in that year became tributary to Akbar. He was still alive in A.D. 1591, when he served under Man Singh in the imperial army which invaded Orissa. 'Tuzuk-i-Jahangiri' (p. 155) :—On the 3rd Isfandiarmuz of the 10th year of my reign (A.D. 1616), it was reported to me (Jahangiri) that Ibrahim Khan (Governor of Bihar) had overrun Kokrah and taken possession of its diamond-washings. This district belongs to *Subah* Bihar, and the river which flows through it yields the diamonds. When the river contains little water, tumuli and hollows are formed. The diamond-diggers know from experience that those tumuli chiefly, contain diamonds over which insects, called by the Hindus *Jhinga,* hover. They pile up stones on all sides of the tumuli, and then cut into them with hatchets and chisels and collect the diamonds from among the sand and stones. Sometimes diamonds are found of the value of a lakh of rupees each. The district and the diamond river are in the possession of the zamindar Durjan Sal. The governors of Bihar frequently sent detachments into Kokrah; but as the roads are fortified and the jungles impenetrable, the governors were generally satisfied with a tribute of two or three diamonds. When I appointed Ibrahim Khan Governor of Bihar, *vice* Zafar Khan, I told him at the time of departure to invade the district and drive away the unknown petty Raja. No sooner had Ibrahim entered on his office than he prepared himself to invade Kokrah. The Raja, according to custom, sent a few diamonds and elephants; but Ibrahim was dissatisfied and invaded the district before the Rajah could collect his men. When he received news of the invasion he was already besieged in the pass where he used to reside. Some of Ibrahim's men who had been sent out to look for him found him with several persons, among them his mother, another wife of his father, and one of his brothers, concealed in a cave. They were deprived of the diamonds in their possession. Twenty-three elephants besides were taken. . . . The district is now subject to me. All diamonds found in the river are forwarded to court. Only

[1] Jour., As. Soc., Bengal, Vol. XL, p. 113.

a few days ago a diamond arrived which had a value of Rs. 50,000 and I hope many more will be added to my store of jewels.' Mr. Blochmann believed that the diamond river alluded to was the Sunk.

To the present day a spot in the Sunk is pointed out by the inhabitants as being a place where diamonds were washed for, and on Rennell's map of India, published in 1788, a diamond mine is indicated on that river.

Mr. Blochmann gives a quotation from a history of the Maharajas of Chutia Nagpur, in which is described a method of testing diamonds for flaws by affixing them to the horns of fighting rams, and states that—

"Jahangiri says the diamonds which Ibrahim Khan had brought from Kokrah had been given to the grinders. 'They were now submitted to me, and among them is one which looks like a sapphire. I have never seen a diamond of such a colour. It weighs several *ratis*, and my lapidaries fix its value at Rs. 3,000, though they would give Rs. 20,000 for it if it were quite white and stood the full test.'"

Colonel Dalton[1] has recorded that the Raja of Chutia Nagpur's family still possess a diamond valued at Rs. 40,000 from these now fabulous mines. As illustrating the methods by which English officials in the olden time shook the pagoda tree, the following will be read with interest. In the year 1772 the Raja appeared before Captain Camar, commanding a force in Palamow, and after exchange of turbans acknowledged himself as a vassal of the Company.

"In regard to this exchange of turbans," writes Colonel Dalton, "the family annals tell a strange tale. In the Raja's turban were some very valuable diamonds, which it is insinuated had excited the cupidity of Captain Camar. The proposal for the exchange emanated, it is said, from him. He declared it was the English method of swearing eternal friendship, but the Captain had no diamonds in his head-dress, and the Raja evidently concluded that he had been rather 'done' by the Company's officer."

This story is so like one, however, which is told of Nadir Shah in reference to the Koh-i-nur that it is possible that it may be apocryphal as regards this locality.

The basins of the Sunk and its sister river, the Southern Koel, are situated to the south of a line of watershed which separates the sub-division of Palamow from the rest of Lohardaga. Neither the geology of this watershed nor that of the valley of the Sunk are as yet accurately

[1] Ethnology of Bengal, p. 163N.

known, and it remains to be seen whether any representative of the usual diamond-yielding rocks of Vindhyan age occur there.

SOUMELPOUR.—If we are correct in assigning the diamond localities mentioned above to the basin of the Sunk, it is almost certain that there were also others to the north of the watershed. These were visited by Tavernier about the year 1665.

He says [1] :—"I come to the third mine, which is the most ancient of all, and in the kingdom of Bengala. You may give it the name of Soumelpour, which is the name of the town next to the place where diamonds are found, or rather Gouel, which is the name of the river in the sand whereof they find the stones. The territories through which this river runs belong to a Raja who was anciently tributary to the Great Mogul, but revolted during the wars between Shah Jehan and Jehangir, his father. So soon as Shah Jehan came to the empire he sent to demand tribute from this Raja, both for the present and the past, who, finding that his revenues were not sufficient to pay him, quitted his country and retired into the mountains with his subjects. Upon the news of his refusal Shah Jehan, believing he would offer resistance, sent a great army against him, persuading himself that he should find great store of diamonds in his country. But he found neither diamonds nor people, nor victuals, the Raja having burnt all the corn which his people could not carry away, so that the greatest part of Shah Jehan's army perished for hunger. At length the Raja returned into his country upon condition to pay the Mogul some slight tribute."

Then follows an account of the route travelled over by Tavernier from Agra *viâ* Allahabad and Rhotas to Soumelpour. He continues:—

"Soumelpour is a great town, the houses whereof are built of earth, and covered only with branches of coco trees. All these 30 leagues (*i.e.*, from Rhotas to Soumelpour), you travel through woods, which is a very dangerous passage, because the robbers, who know that the merchants do not visit the mine without silver, are in wait sometimes to take it from them.

"The Raja lives half a *coste* from the town in tents, set upon a fair rising ground, at the foot whereof runs the Gouel, descending from the southern mountains and falling into the Ganges.

"This is the manner in which they search for diamonds in this river after the great rains are over, which is usually in December. They wait all January till the river be clear, by reason that by that time in some

[1] 'Voyages,' Vol. II, livre II., p. 308, Paris, 1677.

places it is not above 2 feet deep, and in several places the sand lies above the water.

"About the end of January or the beginning of February, both from the town of Soumelpour and from another, which is 20 *costes* higher up the same river, and from some smaller villages of the plain there pour forth about eight thousand persons, men, women, and children, that are able to work. They that are skilful know by the sand whether there be any diamonds or no, when they find among the sand little stones like to those we call 'thunder stones.'[1] They begin to make search in the river from the town of Soumelpour to the very mountains from whence the river falls which are about 50 *costes* from the town.

"Where they believe there are diamonds they encompass the place with stakes, faggots, and earth as when they go about to make the arch of a bridge to drain all the water out of that place. Then they dig out all the sand for 2 feet deep, which is all carried and spread upon a great place for that purpose prepared upon the side of the river, encompassed with a little wall about a foot and a half high.

"When they have filled this place with as much sand as they think convenient they throw water upon it, wash it, and sift it, doing in other things as they do at the mines, which I have above described.

"From this river come all those fair points which are called natural points; but a great stone is seldom found here. Many years have passed during which stones from these mines have not been seen in Europe. It is this which has made many merchants believe that the mine has been lost, but it was not so. It is true, however, that nothing has been drawn from the river for a long time."

As to the identity of this Soumelpour, since it was situated on the river Gouel which flowed northwards to the Ganges, it must have been somewhere in the basin of the northern Koel river and probably within the limits of Palamow. Jefferys in his map of 1768 so places it, but evidently on Tavernier's authority, and not from independent evidence. Much depends on the equivalent value of Tavernier's 30 *costes*, and the nearest approximation which can be made is 81 miles.[2] Now at about this distance south of Rhotas there are on the banks of the Koel the remains of an old town called Semah, lat. 23° 35'; long. 84° 21', which is probably the same as *Semul*, the native name of the silk cotton tree (*Bombax malabaricum*), and Semulpur might very easily be Tavernier's

[1] Can there be any connection between these so-called thunder stones or *pierres de tonnerre* of Tavernier and the *jhingas* mentioned on a previous page? *Jhinga* may have been a technical term.

[2] *Vide* Jour., As. Soc., Bengal, Vol. L, 1881, p. 39.

Soumelpour. Of use as collateral evidence of the supposition that there were diamond workings in this vicinity is the fact that a large picture by a cotemporary artist, representing the attack on the fort of Palamow in 1660 by Daud Khan, which has been described by Colonel Dalton,[1] contains a figure of the *Zamindar-i-kan-i-almas*, or lord of the diamond mine, who is considered to have been a Kol Nagbansi Raja. It seems probable enough that he was the identical personage whom Tavernier found in authority at Soumelpour only five years later.

If this identification be correct then it would seem probable that the source of these diamonds was situated in the same hills as those which separate the basins of the Northern Koel and Sunk rivers respectively.

There is one noteworthy allusion of Tavernier's in the above quotation, and that is to the fact of Indian diamonds going to Europe long before his time. It proves that those writers who have maintained that he first introduced the diamond into Europe are in error. Even in Marco Polo's time, however, and possibly many centuries before it, there was an existing trade as already stated.

There are several notices of diamonds having been found in the tributaries of the Mahanadi, which take their rise in the Chutia Nagpur States of Jashpur and Gangpur, but these statements require confirmation. The Ebe near its sources in Chutia Nagpur is commonly called the *Hira* or diamond river by the natives, and it has also been supposed by some, but apparently without good foundation, to carry down diamonds to the Mahanadi.

In a very remarkable journal[2] by a Turk named Mustapha, who had been educated in France, we find an account of some of the countries traversed by the author between Bengal and Masulipatam in the year 1758. His course was a circuitous one leading him so far to the west as Chutia Nagpur. Unfortunately the manuscript stopped short at Sambalpur. South of Jashpur he seems to have crossed the Main Pât. After describing a severe climb he writes : "These passes are called Ghats in Hindustani, that of Ramghur ; so dangerous of itself was a mere walk to this of Jashpur. Diamonds are to be found in these mountains. There are stones also in the country round Gangpur, 30 *costes* further, as well as at Samalpur. In a word all along the banks of the Ib (Ebe), which, taking its rise near Nowagurh, where it makes a cataract, runs towards the south as far as Samalpur, where it turns eastwards, waters Badrar (?=Bód), and Catlaur, and empties itself, I suppose, between Cuttack and Balasore."

[1] Jour., As. Soc., Bengal, Vol. XLIII, Part I, p. 240.

[2] Dalrymple's Oriental Repertory, Vol. II, 1808, p. 261.

Central Provinces.—In the Central Provinces diamonds are known to have been found in two districts, namely, in the neighbourhood of Sambalpur on the Mahanadi and at Wairagarh in the Chanda district.

Sambalpur District.—Some uncertainty exists as to how far the early notices of the diamond-bearing localities of Gondwana are applicable to those situated in the Mahanadi basin. According to Ptolemy's map[1] the Adamas flows into the Gangeticus sinus (Bay of Bengal) midway between Cosamba on the north (Balasore ?) and Cocala (Sicacole of Arrowsmith's map, the modern Chicacole). The Dosaron and Tyndis rivers probably represent the Godavari and Kistna, so that it is very likely that the Adamas may safely be identified with the Mahanadi. Ptolemy represents the Adamas as flowing through the country of the Sabaræ, across which runs the following description:—"*Apud quos Adamas est in copia,*" which is otherwise given in an earlier edition of the map.[2] "*Sabaræ i his habundat Adamas.*" The upper portion of the river passes through a region named Cocconage, which would include Kokrah or Chutia Napgur.

The first visit to Sambalpur of which there is any published account is described in the narrative of a journey which was undertaken by Mr. Motte in the year 1766.[3] The object of this journey was to initiate a regular trade in diamonds with Sambalpur, Lord Clive being desirous of employing them as a convenient means of remitting money to England. His attention had been drawn to Sambalpur by the fact that the Raja had, a few months previously, sent a messenger with a rough diamond, weighing 16½ carats, as a sample, together with an invitation to the Governor to depute a trustworthy person to purchase diamonds regularly. The Governor proposed to Mr. Motte to make the speculation a joint concern, "in which," writes the latter, "I was to hold a third; he the other two; all the expenses to be borne by the concern. The proposal dazzled me, and I caught at it without reflecting on the difficulties of the march, or on the barbarity of the country, &c."

In spite of his life being several times in danger from attacks by the natives, the loss of some of his followers by fever, and a varied chapter of other disasters, Mr. Motte was enabled to collect a considerable amount of interesting information about the country. Owing to the

[1] Asiæ x. tab. "Geographiæ libri Octo, Gr. et Lat. Opera P. Bertii Lugduni." Bat. 1618. Fol.

[2] Tab. x. "Cosmographiæ," libri viii. Lat. Justi de Albano, Ulmae. 1486. Fol.

[3] "Asiatic Annual Register," London, 1799. The account given in Hamilton's "Hindustan," Vol. II, p. 20, is evidently taken from Mr. Motte.

disturbed state of Sambalpur town, however, he was only able to purchase a few diamonds. After much prolonged negotiation he was permitted to visit the junction of the Rivers Hebe (Ebe) and Mahanadi, where the diamonds were said to be found. A servant of the Raja's, who was in charge there, informed him that "it was his business to search in the River Hebe, after the rains, for red earth, washed down from the mountains, in which earth diamonds were always found. I asked him if it would not be better to go to the mountains and dig for that earth. He answered that it had been done until the Mahrattas exacted a tribute from the country, and to do so now would only increase that tribute. He showed me several heaps of the red earth—some pieces of the size of small pebbles, and so on, till it resembles coarse brick-dust—which had been washed and the diamonds taken out." The description suggests laterite as the matrix from which the diamonds were proximately derived. Messrs. Hislop and Hunter *vide infra* describe the diamonds of Wairagarh as occurring in laterite gravel. In this connexion it may be noted that one of the sources of Cape diamonds is said to be a ferruginous conglomerate.

The next account is by Dr. Voysey,[1] who visited the diamond washings in Sambalpur in 1823 when on his last journey from Nagpur to Calcutta. He states that diamonds were only found below the junction of the Ebe river with the Mahanadi, but other authorities place the limit much further up, namely, at the junction of the Mand and Mahanadi rivers. The miners were at work in the channel between the island and the right bank about 10 miles above Sambalpur. The process, as observed by Dr. Voysey, was the same as is described below.

The most valuable contribution to our knowledge of Sambalpur diamonds is by P. Breton, Esq., Surgeon, Hon'ble East India Company's service. It is contained in a paper entitled "Medical Topography of the districts of Ramgurh, Chota Nagpore, Sirgooja and Sumbhulpore," dated 1825.[2] Mr. Breton quotes from a gentleman who had enjoyed in Sambalpur the best opportunities for obtaining accurate information. He states that the diamonds were only found on the left bank of the river and in the streams from Raigarh, Jashpur and Gangpur tributary to it on that side, up to the Mand. In confirmation that the diamonds came from the north, he says that they had been actually found in the Gangpur, Raigarh and Jashpur States. His description of the method of washing is incorporated below. According to class, the diamonds were valued

[1] Jour., As. Soc., Bengal, Vol. XIII, 1844, p. 859.

[2] Transactions of the Medical and Physical Society of Calcutta, Vol. II, 1826; also issued separately from Government Lithographic Press, Calcutta, 1826.

per masha of 14 grains troy, *first,* 500 Sicca Rupees; *second,* 400 Sicca Rupees; *third,* 300 Sicca Rupees; *fourth,* 175 Sicca Rupees. This was for stones of small weight only, as a diamond of large size was not subject to rule.

The most important part of this paper is the following carefully drawn-up table :—

Table showing the numbers and weight of the rough diamonds found in the Mahanadi between the years 1804 and 1818 by P. Breton, Surgeon Hon'ble East India Company's service.

Years.	Number.	Weight.[1] Mashas.	Ratis.	Troy weight grains.	By whom received from the diamond finders.
Unknown	1	20	4	288	Rani Ruttun Coher.
1804	1	4	...	56	Ditto ditto.
1805	1	7	...	98	Ditto ditto.
1806	None.				
1807	1	22	...	308	Ditto ditto.
1808	1	1	...	14	Ditto ditto.
1809	1	48	...	672	Chunderjee Bhoonsla, Commanding in Sambalpur.
	3	...	3½	7	Chunderjee Bhoonsla, Commanding in Sambalpur.
	1	1	...	14	Sacca Ram Gopal.
1810	2	2½	...	35	Chunderjee Bhoonsla.
1811	1	4	...	56	Ditto ditto.
1812	None.				
1813	1	2	...	28	Mahadeo Rae.
1814	None.				
1815	1	2	...	28	Ditto.
1816	1	...	6½	13	Ditto.
1817	1	2	...	28	Ditto.
	1	...	2	4	Ditto.
1818	1	6	...	84*	Ditto. * This was said to have been brought to the Agent, who forwarded it to Government. Its value was Rs. 5,000.
	1	1	...	14	Ditto.

[1] According to this table the Sambalpur masha = 14 grains troy nearly, the *rati* of which 7 = 1 masha, weighing a fraction under two grains.

"The large diamond found in 1809 was of the third (*Bysh* or *Vaisya*) quality. It was picked up in the month of October at a place called Hirakund, in the bed of the Mahanadi, and its delivery to Rani Ruttun Coher was unluckily delayed on account of her being engaged in performing the funeral ceremonies of her husband's mother, and before they were finished the Mahratta troops arrived and expelled her from the country. A traitorous servant of hers betrayed the secret of the valuable stone to Chunderjee Bhoonsla, the commanding officer, who persuaded the diamond finders to surrender it to him by promises of the grant of a fine village and a thousand rupees. On the following morning, when they appeared to claim performance, they were reproached for bringing a stone instead of a diamond and driven from his presence."

Nothing is known of the subsequent history of this stone; its weight, 672 grains = 210·6 carats, would give it a high rank amongst the largest stones ever found.

The next mention of Sambalpur diamonds is to be found in Lieutenant Kittoe's account[1] of his journey, in the year 1838, through the forests of Orissa. He speaks of the people as being too apathetic and indolent to search for diamonds. His remarks on the localities where they occur seem to be derived from Mr. Motte's account, to which, indeed, he refers.

Although published in the same number of the Asiatic Society's Journal[2] we find a paper dated two years later, or 1840, which was written by Major Ouseley, on the Process of Washing for Gold-dust and Diamonds at Hira Khund. He says that

"the Hira Khund is that part of the river which runs south of the islands. The diamonds and gold-dust are said to be washed down the Ebe River, about 4 miles above the Hira Khund; but as both are procurable as far as Sonpur, I am inclined to think there may be veins of gold along the Mahanadi."

The occurrence of diamonds in the river so far below Sambalpur as Sonpur was probably exceptional. No mention is made by Major Ouseley of the system of throwing an embankment across one of the channels, which is described below; but that method of washing was in practice for many years before the period of Major Ouseley's visit. He describes the operations of individual washers—not the combined efforts of the large number which made that washing successful. The diamonds found became the property of the Raja, while the gold was the perquisite of the washers, who sold it for from Rs. 12 to 15 per *tola*.

Upon what authority the statement is made in the "Central Provinces Gazetteer" that the diamonds of Sambalpur were flat and thin and

[1] Jour., As. Soc., Bengal, Vol. VIII, 1839, p. 375.
[2] *Ibid*, p. 1057.

had flaws in them we are not told; but some of the oldest writers speak of them and those from the adjoining Chutia Nagpur localities as being of the best quality and purest water in India. As to their size the above table affords sufficient evidence. The largest diamond from Sambalpur, seen by the writer, belonged to a native there. The stone, though slightly flawed, had been valued at Rs. 2,500 in Calcutta after cutting.

The last description of these washings to be noticed here is by Surgeon J. Shortt,[1] for it would be an endless task to enumerate all the writers in Europe who have for the most part drawn their accounts more or less directly from Karl Ritter's[2] careful compilation of the information which was available before the year 1836. Inaccuracies innumerable have crept into these accounts, and they are likely to continue to disfigure text-books for many years to come. Dr. Shortt states that search for diamonds was being recommenced in 1855, having been suspended for some years previously.

On Greenough's map diamonds are indicated as occurring in the bed of the Bramini river, but Colonel Ouseley states distinctly that none have been found there.

With regard to the origin of the Sambalpur diamonds, the geological structure of the country leaves but little room for doubt as to the source from whence they are derived.[3] Coincident with their occurrence is that of a group of rocks, referable to the Lower Vindhyan or Karnul series, certain members of which series are now found, or are believed to have formerly existed, in the vicinity of all the known diamond-yielding localities in India, and in the case of actual rock-workings include the matrix of the gems.

In several of the early accounts, the belief is either stated or implied that the diamonds are brought into the Mahanadi by its large tributary, the Ebe. It would not, of course, help to establish the above view as to their origin to say that the Ebe, at least within our area, except indirectly,[4] is not fed by waters which pass over Vindhyan rocks, but we have the positive assurance of the natives that diamonds have not been found in that river, although gold is and has been regularly washed for. On the other hand, diamonds have certainly been found in the bed of the Mahanadi as far west as Chanderpur, and at other intermediate places, well within the area which is exclusively occupied by the quartzites, sandstone, shales, and limestones of Vindhyan age.

[1] Selections from Records, Bengal Government, No. XXIII, 1852, and also Selections from Records, Madras Government, No. XIV, 1855.

[2] Erdkunde Asien, Vol. VI, p. 343.

[3] Records, G. S. I., Vol. X, p. 186.

[4] By a few small streams which rise in an isolated outlying hill, called Gotwaki.

The fact that the place, Hira Khund, where the diamonds were washed for is on metamorphic rocks, may be readily explained by the physical features of the ground. The rocky nature of the bed there, and the double channel caused by the island, afforded unusual facilities, for, in the first place, the retention of the diamonds brought down by the river; and secondly, for the operations by which the bed could on one side be laid bare, and the gravel washed by the simple contrivances known to the natives.

It is impossible to say at present which the actual bed or beds of rock may be whence the diamonds have been derived, as there is no record or appearance of the rock matrix ever having been worked; but from the general lithological resemblance of the sandstones and shales of the Barapahar hills, with the diamond-bearing beds, and their associates in other parts of India, it seems not improbable that they include the matrix. Above Padampur, the Mahanadi runs through rocks of this age, and any one who may hereafter embark upon the undertaking of searching for diamonds in Sambalpur should confine his operations, in the first instance, to the streams and small rivers which rise in the Barapahar hills, and join the Mahanadi on the south. Besides the obvious advantage of being—as would probably be found to be the case—close to the matrix, these streams would afford facilities for obtaining a sufficient head of water for washing purposes. Such works would require but a few labourers, and could be carried on for a much longer period every year, say altogether for eight or nine months, than would be possible in the case of the washings in the bed of the Mahanadi itself.

According to the local accounts, the southern channel of the Mahanadi used not to be emptied in the Raja's time; but from various causes it might be expected to yield, proportionately, a larger number of diamonds than the northern. In the first place, the stronger current in it would be more efficient in removing the substances of less specific gravity than diamonds, while the rocks and deep holes in it afford admirable means for the retention of the latter. Owing to the greater body of water to be dealt with, it would be found to be more difficult to divert than that which flows in the northern channel; but the result in a greater harvest of diamonds would probably far more than compensate for the greater expenditure incurred.

In the country to the south of Sambalpur, in Karial and Nowagarh, where rocks of similar age to those of the Barapahar hills, occur there is no known traditional record of diamonds having ever been found or searched for. It is just possible, however, that the names of several villages in which the word *Hira* (diamond) occurs may have reference to some long-forgotten discovery.

In addition to diamonds, pebbles of beryl, topaz, carbuncle, amethyst, carnelian, and clear quartz used to be collected in the Mahanadi; but there is no record of either sapphires or rubies ever having been found. It is probable that the matrix of these, or most of them, exists in the metamorphic rocks, and is, therefore, distinct from that of the diamonds.

From personal enquiry from the oldest of the Jhiras, or washers at the village of Jhunan, and from various other sources, the following details have been obtained as to the manner in which the operations were carried on in the Raja's time: In the centre of the Mahanadi, near Jhunan, there is an island called Hira Khund (*lit.* Diamond Mine) which is about 4 miles long, and for that distance separates the waters of the river into two channels. In each year, about the beginning of March or even later, when other work was slack and the level of the water was approaching its lowest, a large number of people—according to some of the present inhabitants as many as five thousand—assembled and raised an embankment across the mouth of the northern channel, its share of water being thus deflected into the southern. In the stagnant pools left in the former, sufficient water remained to enable the washers to wash the gravel, accumulated between the rocks, in their rude wooden trays and cradles. Upon women seems to have fallen the chief burden of the actual washing, while the men collected the stuff. The implements employed and the method of washing were similar to those commonly adopted in gold-washing, save only that the finer gravel was not thrown away until it had been thoroughly searched for diamonds. Whatever gold was found became the property of the washer. Those who were so fortunate as to find a valuable stone were rewarded by being given a village. According to some accounts, the washers generally held their villages and lands rent-free; but it is scarcely likely that all who were engaged in the operations should have done so. The people apparently did not regard their (in a manner) enforced services as involving any great hardship; they would be glad to see the annual search re-established on the old terms. Indeed it is barely possible to conceive the condition of the *Jharas* having been at any time worse than it is at present. No doubt the gambling element, which may be said to have been ever present in work of the above nature, commended it to the native mind. The washers belong to an aboriginal tribe, showing neither in their complexions, character of their features, nor hair, the slightest trace of the Negro origin, which has been suggested for them by some writers. Colonel Dalton places them with the Oraons or Dravidians. To this family, it is believed, belong most of the diamond-seekers throughout India.

When Sambalpur was finally taken over by the British, in 1850, the Government offered to lease out the right to seek for diamonds, and in 1856 a notification appeared in the "Gazette" describing the prospect in somewhat glowing terms. For a short time the lease was held by a European, at the very low rate of Rs. 200 per annum; but as it was given up voluntarily it may be concluded that the lessee did not make it pay. The fact that the Government resumed possession of the rent-free villages, while the Raja's operations had been carried on without any original outlay, materially altered the case, and rendered the employment of a considerable amount of capital then, as it would be now, an absolute necessity.

Within the past few years statements have gone the round of the Indian papers to the effect that diamonds are now occasionally found by the gold-washers of Sambalpur. Recent local inquiries failed to elicit a single authentic case, and the gold-washers asserted that these statements were incorrect. Moreover, they do not appear to expect to find any, as they do not even examine the gravel when washing. They appear in fact to have forgotten the art.

Chanda District: WAIRAGARH, Lat. 20° 26′; Long. 80° 10′ (A.S., 73).—The diamond mines at this locality, which is situated about 80 miles to the south-east of Nagpur, are of considerable antiquity. Their identity with the mines of Beiragarh, mentioned in the "Ain-i-Akbari," [1] has been fully established, and it is not improbable that they may have been those which were taken possession of in 1425 by Ahmed Shah Walli Bhamuni, according to Ferishta's history.[2] Whether they are exactly identical with the mines on the Vena, *i.e.*, Waingunga, mentioned in the Brhat Sanhita, which is supposed to have been written in the 6th century, it is impossible to say; but it is certain that Rennell and Karl Ritter were at fault in attempting to locate Beiragurh, the former in Sambalpur and the latter in Berar proper, west of the Waingunga, unmindful that Beiragarh in Gondwana was territory conquered by and in possession of the Rajas of Berar.

These mines, the remains of which are still to be seen on the Sath river, a tributary of the Kophraguri, which is itself a tributary of the Weingunga, are mentioned first, so far as English records are concerned, by Mr. R. Jenkins in his report on the territories of the Raja of Nagpur.[3] He states that they were formerly celebrated, but in his time did not yield sufficient returns to make them worth working. The

[1] Gladwin's Translation, London, 1800, Vol. II, p. 58.

[2] Ed. by J. Briggs, London, 1819, Vol. II, p. 416.

[3] Calcutta, 1827, p. 14.

diamonds were found in yellowish earth (laterite), forming small hills. To this account Mr. T. Wilkinson, who succeeded Mr. Jenkins as Resident, adds[1] that during the reign of Raghoji Bhonsla the mines were worked at considerable expense, but as only a few diamonds were found they were finally given up.

The Revd. Messrs. Hislop and Hunter, in their well-known paper,[2] describing the formations of the Central Provinces of India, merely say that the matrix of the diamonds at Wairagarh is a lateritic grit, the only rock in its vicinity being quartzose and metamorphic. Hence they argue that Malcolmson,[3] and after him Newbold, were wrong in inferring the identity of the sandstones of Central with those of Southern India from the supposed occurrence of the diamond in the former, and they enlarge upon the fact that most of the diamond-bearing deposits, though resting on rocks of various ages, are merely superficial and recent; and that therefore the diamond does not afford a safe guide for correlating the older rocks.

The whole discussion shows misconceptions on both sides which our present knowledge enables us perhaps to clear up. It is quite true that the sandstones of the Central Provinces, which are referred to, are not of the same age as those of Southern India which accompany the diamond-bearing strata. They are in fact very much younger, and Messrs. Hislop and Hunter were no doubt correct in asserting that the diamonds found in the lateritic gravel had not been derived from them. But the mention of quartzose metamorphic rock confirms what is independently likely, namely, that the great basin of Lower Vindhyan or Karnul rocks, which occupies the upper portion of the Mahanadi Valley, stretches into the neighbourhood of Wairagarh, and it may therefore be suggested, with a considerable degree of probability, that the ultimate derivation of these diamonds is from a stratum occupying a horizon identical with that which constitutes the matrix of the Sambalpur diamonds, and as that in a general way has already been correlated with the diamond horizon in the Karnul rocks, the theories of both sets of observers contained hypotheses partly correct and partly erroneous, the correct portions respectively supplementing one another. Malcolmson and Newbold were right in supposing that the diamonds of Wairagarh indicated the existence of rocks of the same age as those of Southern India (the Karnul formation); but were wrong in supposing that the fossiliferous sandstones which they referred to included the

[1] Calcutta Jour. of Nat. Hist., Vol. III, p. 290.
[2] Quar. Jour., Geol. Soc., Lond., Vol. XI, p. 355.
[3] Jour., Bombay Br. Roy. As. Soc., Vol. I., p. 520.

source of the gems. On the other hand, Messrs. Hislop and Hunter, while pointing out the latter mistake, did not realise the existence of another formation close by from which the gems probably did originally come. They seemed to regard the diamonds both here and elsewhere throughout India as being a product of superficial deposits without reference to the nature of the beds upon which they rested.

The latest visitor to these mines, who has published any account of them, is Mr. Beglar,[1] but his notice is a merely incidental one. He says that the old workings are shallow pits which cover but a small extent of ground.

The examination of the geological structure of this neighbourhood, and a comparison of it with that of the Mahanadi region above Sambalpur, has still to be accomplished. If the stratum from which the diamonds have ultimately been derived should be identified, and if its lateral extension should prove to be coincident with that of the Vindhyan or Karnul rocks of this region, then we shall have a diamond tract equal in area, if not greater, than those of either Karnul or Bundelkhand.

Bundelkhand.—The mines of Bundelkhand are generally known as the Panna mines, but in this account it will be necessary to distinguish the mines near the town of Panna from those which are situated in other parts of the province. The following list by no means includes the names of all the places where there are diamonds, but it would be useless to add to the number, as those selected are sufficiently representative. They are Panna (or Punnah), Kamariya, Brijpur, Majgoha, Udesna, Sakeriya, Baghin, Myra, Etwa, Bargari, Saya Luchmanpur, &c.

The diamond bed proper, which is a conglomerate, belongs to a group at the base of the Lower Rewah division of the Upper Vindhyans, which is distinguished as the Panna shales. Outlying, uncovered and partly denuded patches of these rocks sometimes occur as remnants of old spurs from the tableland. Occurring thus without the usual covering of sandstone which is found on the tableland, early observers were puzzled to account for the apparent difference in mode of occurrence, and thus some confusion arose in their accounts.

No very large diamonds appear to have been found here, but the quality is good; the crystalline forms are usually simple octohedrons or dodecahedrons.

Panna, Lat. 24° 43′ 30″ N.; Long. 80° 15′ E.—The mines which are situated about 2 or 3 miles to the north-east of Panna have been frequently visited and described [2] during the present century.

[1] Report on the Archæological Survey of India, Vol. VII, p. 129.

[2] 1813.—Hamilton, Dr. F. Edin., Phil. Jour., Vol. I, p. 49: 1826.—Pogson, Capt. W. H. History of Boondelas, Calcutta, p. 169: 1827.—Franklin, Capt. Trans. Roy. As.

In Captain Franklin's time the mines at this locality stood next in esteem to those at Kamariya. Mr. Medlicott gives the following account of them. At the time of his visit the miners had not got down to the diamond-bearing stratum, which is not laid bare till about March in each year :—

"The rock diggings near Panna do not cover a surface of more than 20 acres; they are on a low, flat, rising ground at the base of the slope from the Kymore scarp; there were five or six pits in progress. The section is—3 feet of soil, on a smooth surface of boulder clay; this latter contains large and small rounded boulders of sandstone, possibly the remains of masses fallen from the retreating cliff of the Rewah ridge; its thickness is very variable from 2 to 12 feet, due to the uneven surface of the subjacent rock; pebbles of the laterite iron ore are common along the bottom of the boulder bed.

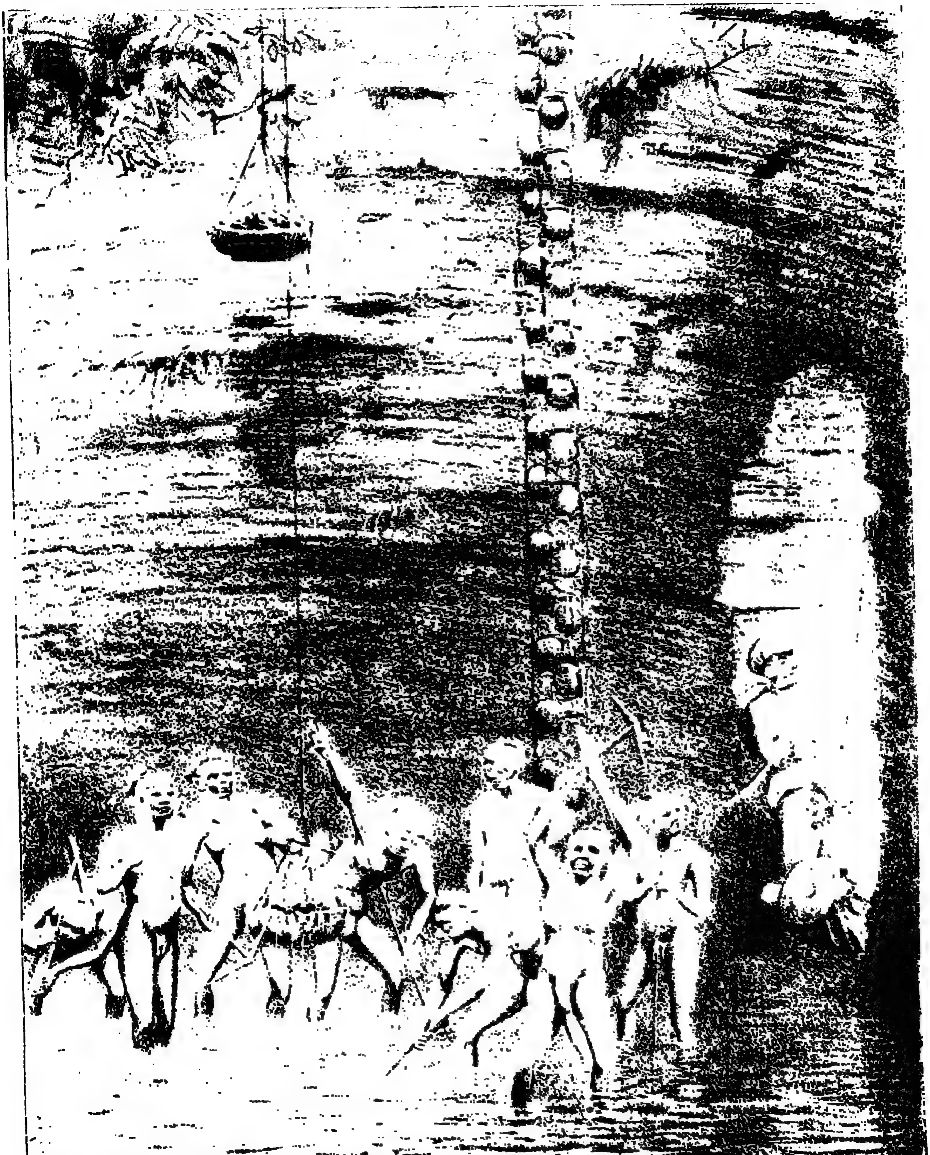
"The top 3 feet of the hard rock looks more like a reconstruction of materials than a rock *in situ*. It is an irregular, streaked mass of clay, with occasional strings of broken grit bands; the crushing action which is so manifest in these upper layers extends itself to those below; contortion and fracture on a small scale are evident throughout."

These appearances are considered to be due to the falling of heavy masses of rock from the cliff face, which formerly existed, as it was undermined from below.

In the Panna mines, although the diamond seam is deeper than elsewhere, owing to the broken nature of the overlying strata it is not reached by a shaft, but the miners go to the immense labour of excavating great pits, 25 feet in diameter, and often over 30 feet deep, for the sake of the small patch of diamond conglomerate thus uncovered, which, according to Captain Franklin, is frequently not more than a span thick.

The system of mining in practice at Panna will easily be understood from the illustration, Plate I, by Mr. Jules Schaumburg, who visited the mines with M. Rousselet in the year 1867. The almost naked miners enter the pit by an inclined plane and work knee-deep in water. The stones and mud which they excavate are put into small baskets which are drawn up by hand. The Persian wheel turned by four bullocks is insufficient in power to thoroughly drain the place. The illustration represents the band of earthen vessels by which the water is lifted.

Socy., Vol. I, p. 277 : 1829.—The same : As. Res., Vol. XVIII, p. 100 : 1830.—Jacquemont : Voyage dans l'Inde, Tome I, p. 399 : 1833.—Anonymous : Indian Review, Vol. III, p. 119 : 1840.—Adam, Dr. J. : Jour., As. Soc., Bengal, Vol. XI, p. 399 : 1860.—Medlicott, H. B. : Mem., G. S. I., Vol. II, p. 65 : 1874.—Rousselet M. : L'Inde des Rajahs, pp. 441-443 1874.—N. W. P. Gazetteer, I, p. 565 : 1877.—W. L. Willson : M. S. Report.



The stuff on reaching the surface is placed on stone slabs and is searched, the searchers being under the charge of guards, as are also the miners.

KAMARIYA.—The mines situated in the vicinity of the abovenamed village are described by several authorities.[1] The following by Mr. Hacket is the most complete account :—

"The diamond stratum, locally called *kakru*, consists of a conglomeratic sandstone made up of pebbles, one-eighth to one-half inch diameter, imbedded in a rather fine matrix, which also includes clay galls. The lower Rewah sandstone here stretches out a considerable distance in front of the scarp, and the pit was just on the northern edge of this terrace, some 20 feet below the summit, and itself about 10 feet deep. On the top of the diamond bed was a foot or so of hard thin flaggy sandstone, and about 7 feet of the same mixed with shale. A little further to the south and west, on this terrace, was an old pit between 30 and 40 feet deep, but the bottom was filled with water, so that the rocks immediately above the diamond bed could not be seen; there were, however, certainly 10 to 15 feet of shale between it and the lower Rewah sandstone. In all the pits examined there must have been 10 to 20 feet of shale intermediate. The Pannas are here very thin, so that this position is not much above the top of the Kaimurs (the lowest group of the Upper Vindhyans). There are some small outlying hills to the north at the village of Bungla and north of Babupur. The former is about 50 feet high, with Kaimurs at the base, then 15 to 20 feet of shale capped in turn by the lower Rewah sandstone; this was the only outlying hill in which the shales were seen (on account of the northern overlap). A few hundred yards to the north-east another little hill has been excavated in every direction by the old diamond searchers. Again, at Babupur are numerous old pits, and some sufficiently well preserved to admit of examination. They are about 15 feet deep exposing sandstone with thin flaggy beds at the top, but no shales.

"A bed of fine, brown sandstone, including fragments of a green silicious rock, and bits of red and green shale, was traced from Bumbhen to Kissengurh, which is not impossibly the continuation of the diamond bed; that the natives do not work to the east is no proof that the beds do not continue in that direction. This is evident from the fact of there being no pits at Bangla, notwithstanding that the hills all round, even to the north, have been extensively worked. It is, therefore, almost certain that at Bangla the diamond bed exists though untouched."

[1] Franklin, Capt.: As. Res., Vol. XVIII, p. 105: Medlicott, H. B.: Mem., G. S. I., Vol. II.

Owing to there being a strong roof here it is possible to excavate for some distance from the sides of the pit with safety. The occurrence of green pebbles is considered to be a good sign of the presence of diamonds according to Franklin.

Mr. Medlicott notices the transition of the conglomerate from its position among the shales to its condition as a pure, fine sandstone conglomerate.

In reference to the extension of the conglomerate, he remarks that from the nature of the case—its occurrence among fine beds—it has *per se* a precarious existence. He finds it difficult to determine the reasons why the deposit has not been worked in some localities as at the base of the hills. In some cases, in the outlying patches, the margin of the deposit has been reached; in others it may have died out; the latter state of things might be readily ascertained were a few trenches dug in selected localities.

Birjpur.[1]—Regarding the mines at this locality, which differ essentially from those just described, both Captain Franklin and Mr. Medlicott have written. The latter says[2]:— "To the east of Kamariya the position and form of the *Kakru* becomes modified just west of Birjpur; it is a 2 feet bed of clear conglomeratic sandstone, resting on the strong beds of pure sandstone and is worked at the surface; the ledge which it caps presents an abrupt ridge along the right bank of the Baghin, and to the south runs into the hills, being apparently a flat spur and not an outlier. On the east slope of this spur these sandstones are seen to overlie some 20 feet of the variegated shales."

The position of this deposit is said to be somewhat puzzling, as there is but one conglomerate, and it seems to be continuous though it rises in the section from west to east. The pebbles do not vary in character while the matrix does.

On the accompanying map (III), the positions of numerous mines are indicated, but with the exception of those just mentioned, which are more or less appropriately termed *Ghaira,* deep mines, all are in superficial accumulations of detritus, not in the old original conglomerate. The term *chila* appears to be restricted to the mere surface scratchings as distinguished from the pits, whether in the rock or in the accumulated masses of detritus.

Majgoha or Majgama.—This is the most western point in the area where diamonds are known to occur. Their mode of occurrence there

[1] Variously written Brijpur, Bridgepur, &c.
[2] Mem., G. S. I., Vol. II., p. 69.

too is somewhat unusual. It has been described by Captain Franklin and Mr. Medlicott.

The former describes the site of the mine to be in a huge basin like an inverted cone, 100 yards wide and about 100 feet deep. Two-thirds of the basin are filled with a green mud containing a calcareous matter, and with a thick covering of calcareous tuff. The diamonds occur in the green mud, and the natives whose appliances do not admit of their going below a depth of 50 feet, say that the diamonds become more abundant as a shaft descends. Captain Franklin considers this and the deposit in the Baghin valley as being places in which an improved system of mining might be applied with good effect.

Mr. Medlicott says of it :—

"The filling in is certainly peculiar: the structure is like coarse foliation, a net-work of strings of calc spar, inclosing laminæ and small lumps of green clay.

"In the only hole I saw, they were working the yellow clay from the crevices of this; but the men told me that at a greater depth there are alternating layers of green mud, and of its mixture with calc spar in which diamonds are found."

Udesna.—The matrix here, which consists of pebbles and boulders under an irregular thickness of yellow clay, containing both kunkur and laterite, does not require to be broken up, the clay being separable readily by washing, but the yield is not so certain as it is in the old conglomerate.

Sakeriya.—A description in the "North-west Provinces Gazetteer,"[1] quoted from Pogson's Boondelas,[2] gives a very incorrect account of the mines of this locality. It is stated that the diamonds are found below a stratum of rock, 15 to 20 feet thick, which takes the natives months and even years to cut through with their chisels, the rock being rendered friable, by lighting fires upon it. It is probable that this description really referred to some other locality where there were rock mines, possibly Kamariya.

Both Captain Franklin and Mr. Medlicott give very different accounts of it. That by the latter is as follows :—

"As at Udesna, there is a variable depth of clay, the middle third being kunkury and the lower lateritic; below this the clay becomes charged with gravel, pebbles, and boulders, these rapidly increasing in size to great angular blocks of sandstone, scarcely moved from their

[1] Vol. I, p. 566.
[2] Calcutta, 1828, p. 169.

original beds; it is from between these that the best stuff is got, a stiff unctuous clay, with quartz gravel through it. Above these deep pits, which are never far from the stream, and well up on the slope of the Rewah sandstone, there are diggings in the surface lateritic gravel.

Baghin or Baghe.—Mr. Medlicott's description of the mines at this locality is as follows :—

"At the upper end of the gorge of the Baghin river there are two falls of 200 feet each, and there are workings throughout the whole length to Kalinjar. The principal diggings were at the lower end of the inner valley; they were removing some 12 feet of dark-brown clayey sand to get at the boulder bed, in the base of which the diamonds are found, but both here and below the narrow gorge the gravel at the surface of the river-bed is much worked. The natives spoke to me of a European, who some twenty years ago had made an attempt at mining on a large scale. His diggings were on the flanks of the limestone hill, some 50 or 100 feet over the river, the ore being a jasper gravel gathered from the deep surface crevices of the limestone. As well as I could understand their pronunciation, the man's name was Berkeley, but I have not seen any written account of his experiment; the remains of his wash-pits and picking floors are there still." This European was possibly Captain Pogson, who describes his operations at this very spot. He himself found two small diamonds which the labourers considered augured well. But his mine was flooded and soon abandoned as he had to join the army on the breaking-out of the Pindari war.[1]

Other mines are situated at Myra or Maira, Etwa, Borgori, &c. Pogson also says that diamonds have been found in Kalinjar and close to the hill.[2]

Saya Lachmanpur.—At a place of this name, on the summit of a hill called Bindachul, about 14 miles from Panna and in Pargana Badausa, of the Banda district, there is a diamond mine, of which one-eighth only belongs to the Government, and this portion is leased for Rs. 125 per annum.[3] As it is believed that no revenue is drawn at present from the mines in Southern India, this one-eighth of a mine enjoys the unique position of yielding the sole contribution from diamond mines towards the finances of British India.

Mr. Medlicott declines to believe in the instinct of the natives as evinced by the capricious distribution of the surface diggings in Bundelkhand. There are many valleys in which the relation to the underlying

[1] Histy. of Boondelas, p. 170.
[2] Histy. of Boondelas, p. 170; and N. W. P. Gazetteer, Vol. I, p. 449.
[3] N. W. P. Gazetteer, Vol. I, p. 98.

rocks is such as to make it almost certain that the alluvial deposits contain diamonds, and yet there are no traces of workings. On the other hand, some of the workings prove the former extended range of the rock matrix which has been broken up by denudation.

The following anonymous account of the Panna mines which seems to be well worthy of reproduction, has been extracted from an Indian newspaper:—

"The finances of the Maharaja are principally derived from his diamond and iron mines, and the following particulars as to how the mines are worked will prove interesting.

"In granting licenses to natives the invariable rule of the Raja is to restrict the claim to diamonds below six *ratis* in weight, on which a percentage of Rs. 25 or upwards is charged. The party is then allowed to search in any spot within the territory, excepting such as are given to Brahmins for sacred purposes or are reserved for the Ranis or other relatives of the Chief. The mines of Kahmura (or Kamariya) and Panna are the most celebrated, and are excavated to a depth of from 15 to 50 feet. They lie within the bounds of the rocky matrix. Those at Majgama have also been very imperfectly used, the mining not going below 50 feet, at which depth the water overflows, and the *tuadars* (or masters of the mines) are compelled to stop at this limit for want of a method to pump them dry. The *chila* and superficial mines are to be traced all over the diamond tract, manual labour being cheap, as the poorest subjects of the State work them. From the commencement of the rains to the beginning of the cold season the mining goes on, since a plentiful supply of water can be had in all parts of the State—an article highly necessary to facilitate the search, as the matrix, after being dug out, is placed by small quantities in a trench, and then washed to clear it of the clay which adheres to it. A spot on the surface of the mine is made smooth with the hand, and on it the gravel is spread, and a diligent search made for the diamonds. Almost three-fourths of the people of Panna and the adjacent villages derive their living by working either for themselves or as hired labourers for others. When employed on their own account it is not unusual to hear them complain of no luck for months and months. Indeed, I never knew a native during the short time I was in the State, who said he had found a diamond, but I was told that the following is the way natives carry on when at the mines. The avarice of the predecessor of the present Maharaja of Panna knew no bounds. The mines being the chief source whence his revenues were obtained, the native *tuadars* were never spared when they found diamonds, but had the most unreasonable taxes imposed upon them. This mis-

chievous system, and the impolitic rule that all diamonds above six *ratis* become the *boná fide* property of the Maharaja, seem to have engendered in speculators a vindictive spirit, not only to evade the heavy duties, but to cheat the State of the produce of the mines altogether. Every poor *tuadar* has a petty banker, who supports his constituents and his family with the necessaries of life, on the understanding that every diamond found by them should be sold to him, out of the amount of which he is to pay himself. In fact, a *tuadar* of the lower order is but an instrument to enable the mahajans to rob the Maharaja, and it is a well-known fact that though these harpies hoard up wealth through the medium of their artful constituents, they will on all occasions, in order to evade suspicion, plead poverty and distress, whilst they carry on a clandestine trade of diamonds between Mirzapur, Benares, Allahabad, and Jabalpur. Some years ago, one of these mahajans was detected in defrauding the State of diamonds during a long series of years to the amount of Rs. 43,000. He was imprisoned and threatened with punishment, and to avert this he refunded Rs. 16,000 and acknowledged having embezzled to the extent mentioned. It is well known that the Maharaja is robbed of large and valuable diamonds yearly. I believe only one European has ever tried working at the Panna mines, and this was in 1833, when a license was granted him, and the following were the terms in his license:—On diamonds of 1 to 7 *ratis*, 15 per cent. on the value; from 7 to 10 *ratis*, 33 per cent.; from 10 to 15 *ratis*, 50 per cent.; from 15 to 20 *ratis*, 66 per cent.; from 20 *ratis* and upwards *boná fide* the property of the Maharaja, he having the option to reward the *tuadars* as he pleases. The expenses for working the mines at that time were as follow:—

For one month with 20 sets of labourers—

	Rs.
20 Bildars at Rs. 2 per month	40
15 Waterwomen do.	30
4 Sepoys at Rs. 3	12
Implements for digging, &c.	40
Total	122

"It shows how cheap labour was in those days, whereas at this time bildars are getting Rs. 12 and Rs. 14 a month. The European (his name is not given, and I copy from an old Government record) says:—In embarking in this enterprise the chief evil to be guarded against is theft. A strict eye should be kept over the labourers during the hours of their work, as they not only pilfer and conceal these stones in the very mines they are working, but will, in cases of emergency, swallow them! It is said that before the British supremacy became paramount in these parts,

delinquents of this description have suffered death rather than confess having stolen the gems which have afterwards been discovered in the ashes of their remains."[1]

So far as can be ascertained, the Panna mines have never yielded any diamond of remarkable size. But there can be little doubt that vast quantities of diamonds have been produced there which have commanded relatively a higher price than Brazilian and Cape diamonds. The influx of the latter into the Indian market of late years has, however, seriously depreciated the selling value of Indian stones, and but few find their way to the Calcutta market. According to Dr. Hamilton, in his time, 1813, a good many stones were found worth from Rs. 500 to Rs. 1,000, and he says that the Raja had one supposed to be worth Rs. 50,000.

Captain Franklin states that the diamonds were classed under six principal heads[2] and a number of minor sub-divisions according to their lustre, water, colour, freedom from flaws, &c. Of the first class called Lilwaja, there was only one sample in Panna in his time. Into all these particulars it is perhaps not necessary to enter further here. But it may be of interest to quote the opinions of the various authorities as to the revenue derived by the Rajas from this source. In the time of Akbar the value of the diamond mines, it is said, was 8 lakhs of rupees a year (£80,000). And they also formed a considerable source of public revenue as well as of mercantile profit during the government of the Native Chiefs of Bundelkhand and of Ali Bahadoor, its last Mahratta conqueror. In 1750, during the reign of Raja Chuttersal, the duties levied at Panna and the profits from the diamond mines amounted to 4 lakhs, £40,000, per annum. It was added that the modern profits are supposed to be comparatively insignificant, *and are wholly relinquished to the Native Chiefs by the British Government.*[3]

Franklin estimated the produce at Rs. 1,20,000 per annum, of which the Panna Raja received one-fourth, other portions going to the Rajas of Banda, Chirkhari, and Jaitpur, and the remainder to the miners, &c. M. Rousselet estimated the produce in 1867 to amount to from francs 1,500,000 to 2,000,000; *i.e.*, to from £60,000 to £80,000, but it is necessary to caution the reader, as this may be, and probably is, an over-estimate. For the purpose of clearing up this point reference was made through the proper channel to the Raja of Panna, but it is

[1] It is apparently this document which is printed in the Indian Review, Vol. III, p. 120.

[2] Captain Pogson mentions four only—1, *Motichal*, clear and brilliant; 2, *Manik*, greenish; 3, *Panna*, tinged with orange; and 4, *Banspat*, blackish. History of the Boondelas, p. 169.

[3] W. Hamilton. Description of Hindustan, 1820, Vol. I, p. 326.

to be regretted that in this case, and also in regard to some other enquiries of a similar character, which have been made while this book was in preparation, no complete information could be obtained.[1]

DIAMOND-MINING BY EUROPEANS.—In order to give the foregoing remarks a practical application it may be well to briefly discuss the prospect of diamond-mining in India if undertaken under European management.

As has been already related, in each of the three great tracts at Chennur, at Sambalpur, and at Panna, attempts have been made by Europeans to mine for diamonds, but in no instance have their operations proved to be successful. How far success was deserved by the manner in which the operations were carried on it is impossible to state, but it is believed that they were on a very petty scale. Regarding the question, however, from a general point of view, it is easy to see that there are causes which must tend to have an unfavourable effect upon the success of undertakings of this nature.

In the first place, however, it may be well to premise that there is not the least ground for supposing that there has been any real exhaustion of the localities where mining is possible. On the contrary the result of the systematic geological examination of the different areas has been to show that the diamond-bearing strata have a wider extension there than the actual miners ever supposed, though not so wide as some writers have concluded, by a process of including the most distant localities in one tract, and then computing the total area.

That the ancient miners possessed and acted on a kind of rule-of-thumb knowledge of the characteristics of the diamond-bearing strata in different tracts respectively is almost certain; but that they applied such knowledge inductively to distant tracts is extremely doubtful. The probability is that in each neighbourhood operations were commenced in consequence of chance discoveries.

Prospecting far and wide we may be sure was never undertaken by natives, and it is doubtful whether there was any intercourse or communication between the workers at distant localities.

With scientific guidance, backed by capital and proper mining appliances, it may appear at first sight that mining by Europeans ought to succeed, but from what has already been said in reference to Bundelkhand, it will be gathered that there are in diamond-mining certain

[1] Should it be received in time it will be incorporated in an appendix. The average annual value for the last three years of the diamonds found in the Chirkhari State has been communicated to the Geological Survey by the Political Agent, and it amounts to only Rs. 5,564, of which the State received about one-fifth.

peculiarities which distinguish it from most, if not all, other forms of commercial enterprise, the facilities for peculation in consequence of the readiness with which the gem may be conveyed is of course the principal of these. There must necessarily be a considerable amount of individual hand-work.

It would almost seem, in fact, that except under a system of slavery the diamond cannot be worked for profitably in India. The present system, though not so called, practically amounts to much the same thing; the actual operatives are by advances bound hand and foot to the farmers of the mines, who are content to wait for months together without any return; their outlay too is very small, no heavy expenditure of capital being involved.

No particular stress need be laid on the fact that the several attempts in Southern India, at Sambalpur, and at Panna to work mines under European management have hitherto failed. These failures may have been due to causes with which the conditions above alluded to have nothing to do; they may have resulted from simple incompetency, death, or sickness, &c.

Mr. King, in writing of Southern India mines, says that it is not to be expected that diamond-mining would, except by a mere chance, prove a rapid road to fortune. But for those content with a slowly paying occupation and a hard life, involving close personal supervision of the workers, it would pay, provided such persons possessed capital sufficient to last them some years.

Although the most famous mines, those of the so-called Golconda region and of Panna, now belong to native chieftans, with whom it might be difficult to arrange any practical scheme of working by means of British companies, still the mines of Kadapah (Cuddapah), Karnul, Sambalpur, and Chutia Nagpur are in British territory.

MYTH REGARDING INDIAN DIAMOND-SEEKING.—The myth made familiar to everyone by the travels of Marco Polo and Sindbad the Sailor is of great antiquity; perhaps one of the best accounts of it is by Nicolo Conti, who travelled in India in the early part of the 15th century. He says that at a place called Albenigaras, 15 days' journey north of Bizengulia, there is a mountain which produces diamonds. The writer[1] recently attempted to show that Al'Benigaras might be Beiragarh, the modern Wairagarh; that it was so is doubtful, but its identity is perhaps immaterial. Marco Polo undoubtedly referred to the localities in the Kistna Valley. Nicolo Conti says that the mountain being infested with serpents it is inaccessible, but is commanded by another

[1] Jour., As. Soc., Bengal, Vol. L, p. 43.

mountain somewhat higher. "Here at a certain period of the year men bring oxen which they drive to the top, and having cut them into pieces cast the warm and bleeding fragments upon the summit of the other mountain by means of machines which they construct for the purpose. The diamonds stick to these pieces of flesh. Then come vultures and eagles flying to the spot, which seizing the meat for their food fly away with it to places where they may be safe from the serpents. To these places the men afterwards come and collect the diamonds which have fallen from the flesh." He continues with an account of how other less precious stones are obtained, and this part of his description is that of ordinary Indian diamond-mining.

On a previous page allusion has been made to the native belief that the diamond mines were under the special patronage of the goddess Lakshmi, and that sacrifices were made to propitiate her. There is reason for believing that sacrifices were made on the opening of new mines, and probably also when the supply of diamonds ran short. The late Mr. M. Fryar, when visiting a stream-tin washing at Maleewoon, in Tenasserim, was requested first to remove his boots, being told that on a former occasion a European visitor insisted on walking up to the stream with his boots on, and that in consequence it ceased to yield ore until two buffaloes had been sacrificed to appease the insulted guardian spirits or Nâts of the place.

This is scarcely a suitable place for fully illustrating this subject, but the following, if put side by side with Nicolo Conti's account, so completely explains it that it will perhaps be sufficient for present purposes.

Dr. J. Anderson, in his report[1] on the expedition to Yunan, describes having witnessed the sacrifice of two buffaloes by the Kakhyens to the Nâts or evil spirits. The animals having been slaughtered on two bamboo altars, were cut up and the meat distributed, *certain portions with cooked rice being placed on a lofty bamboo scaffolding for the use of the Nâts.* It goes without saying that birds would help themselves to these offerings.

Credulous travellers in early times might very possibly have supposed, on witnessing such a preliminary sacrificial rite, if at a diamond mine, that it was an essential part in the search for diamonds, and it would not require any very great stretch of Oriental imagination to build up the fable on such a substratum of fact. The bamboo scaffolding in all probability represents the machine mentioned by Conti.

Graphite or Plumbago: General Remarks.—Pure graphite, as found native, contains from 95 to 99 per cent. of carbon. The commercial values of the different qualities ordinarily found depend upon the amount

[1] Calcutta, 1871, p. 40.

of impurity which they include. Foreign matters can be got rid of by grinding, washing, and the use of acids, and the purified product may be employed for all the purposes to which graphite is applied, but the process is costly, as the smallest particles of grit are injurious. Formerly pencils were almost exclusively sawn out of the fine-grained massive qualities, such as that produced in the now exhausted mines at Borrowdale, in Cumberland.

The former high value which this still valuable substance possessed has no doubt been the cause of much of the importance with which deposits in various parts of India have been temporarily invested. The only one of these, save possibly that at Vizagapatam, which, taking into consideration its quantity and the means of transport, is of any present promise, is that which occurs over a wide tract in Travancore. Although the opinions of experts many years ago were unfavourable, it is conceivable that an increased demand and improved and more economical methods of purification might render its exploitation a profitable undertaking. At the same time the possibility of further search proving the existence of a quality equal to the better kinds found in Ceylon cannot be denied, as the probability is that the including rocks are of identical age.

At the present day nearly all the plumbago of commerce comes from Ceylon. It is classified under three heads, the prices of which in the London market on the 11th March 1881 were as follows:—

Lump	£17-10 to £19 per ton.
Chip	£10-10 to £14 „ „
Dust	£ 8-10 to £10 „ „

Although graphite occurs in many parts of the United States, it is only mined successfully at Ticonderoga in the State of New York.

It may be of interest here to enumerate the principal uses to which this substance is put. It is used in the manufacture of pencils, crucibles, stone or grate polish, as a lubricator for machinery, electrotyping, faces for moulds or foundry facings, refractory mixtures, and for giving a protecting surface to the interior of blowing cylinders in blast furnaces.

The pencils of the present day are made by mixing very finely divided graphite with a particular kind of clay in varying proportions according to the shades required. There is much adulteration in the black leads commonly sold; but for information on these subjects, and on the various processes employed, reference may be made to the usual text-books.

Madras: Travancore State.—TRIVANDRAM, Lat. 8° 30′ N.; Long. 77° E.—The first discoverer of the existence of graphite in Travan-

core appears to have been General Cullen, who in 1845[1] traced it in the gneiss south of Trivandram northwards as far as Cochin. Some samples, which were forwarded to the Asiatic Society from a locality south of Trivandram, were considered by Mr. Piddington to be too soft and scaly for the manufacture of pencils, *i.e.*, by the old method. The matrix appears to be a pseudo laterite formed of decomposed gneiss *in situ*. One specimen now in the Geological Museum is covered with a salt efflorescence, and certainly it may be said, judging from the various original samples in the collection, that without much grinding and washing they could not be made available even for the inferior purposes for which graphite is employed. Samples from this locality, Vizagapatam, and Almora were exhibited in London at the exhibition of 1851.

In a subsequent communication General Cullen describes his further efforts to open up one of the deposits and prepare large samples for despatch to London. The situation of his mine was near Ponalaul, in the Oolamalakul property, about 10 miles north-east of Trivandram, on the road to Arinaud. About 1¼ tons. of the stuff was extracted, which yielded 1,000 lbs. of pure graphite. As in all such calculations the estimate of cost, 100 lbs. per rupee at Trivandram or even less, is fallacious, since it does not appear that the General's own pay, while he superintended the operations, was included in the actual expenditure incurred, nor does it follow that the cost of extracting at the outcrop would not be exceeded when regular mining operations had to be commenced.

In 1855 Dr. Royle[2] described specimens from Travancore, which were lamellar, as being soft but brilliant, and similar to what was at that time imported from Ceylon at a cost of £8 to £10 a ton. But the general opinion of experts and manufacturers of pencils in England, to whom samples were submitted, was that they were too gritty and impure to be of much value. Some, however, took a more sanguine view. Mr. Ruel, a crucible manufacturer, estimated the value for his purposes at 8 shillings a hundredweight though 14 shillings are sometimes given.

Since the above was written, Mr. King has sent samples of a much purer looking graphite, obtained during the present year from a deposit close to Vellurnad, near Arinaud; probably this locality is the same as General Cullen's. The veins in which it occurs are said to cross the strike of the gneiss. Apparently this not easily accountable mode of occurrence has been observed in America also.

[1] Jour., As. Soc., Bengal, Vol. XIV, p. lxiv.

[2] Jour., As. Soc., Bengal, Vol. XXIV, p. 203; and Madras Journal of Lit. and Sci., Vol. I, new series, 1856, p. 257.

It is perhaps needless to observe that the smallest particles of grit in graphite for pencils is most prejudicial, whilst for lubricating purposes, if graphite be not absolutely pure, it may be most injurious to machinery; for the coarser purposes of making crucibles the presence of iron would certainly diminish the refractory properties of the material.

Tinnevelly District.—General Cullen states that he obtained pieces of graphite of the size of a small egg and with a laminated structure in some *kankar* in Tinnevelly. In another part of his paper he speaks, however, of the matrix being limestone or gneiss. Possibly some specimens, now in the Museum, which are in a crystalline limestone, but which are labelled from Trivandrum, may have come from this locality. In a letter from the Resident at Travancore (*i.e.*, General Cullen), which is quoted by Dr. Royle, the graphite is said to occur in disintegrated gneiss, and at Culdacurchi and Ambasamudram in *kankar*. The precise sense in which the term *kankar* is used may be doubtful.

There is a specimen of graphite now in the Museum said to have been obtained in the red hills near Madras.

Kistna and Godavari Districts.—According to Mr. King[1] bands of very quartzose rock, with graphite sparingly distributed through them, occur close to Bezwada, in the Kistna district; and fragments of graphite occur in the streams which traverse the Beddadanol coal-field; these last, it is believed, have been brought down from the gneiss further north.

Vizagapatam District.—Graphite is stated[2] to be found near Kasipuram, in the territory of the Maharaja of Vizianagram, also at Rampilli of Salur, and one or two other localities. It is used for giving a polish to pottery, and can be had in any quantity at a rupee for 24 lbs. at Vizianagram. A sample, now in the Geological Museum, is included in a heavy ferruginous gneiss, and is not of very promising appearance.

Bengal: Lohardaga District.—A loose fragment of gneiss containing lamellæ of graphite was found in the bed of the Koel river close to the village of Hutar, which has furnished a name for a coal-field.

Central Provinces: Sambalpur District.—DARAMGARH, Lat. 20° 24′ 30″; Long. 83° 18′ 30″; DOMAIPALI, Lat. 20° 49′; Long. 83° 4′—At both the above localities, which are situated in the Patna zemindari, deposits of graphite, which had previously been brought to the notice of the district officials by the natives, were examined by the writer. The graphite occurring in both cases merely as a constituent of some

[1] Records, G. S. I., Vol. VII, p. 160.
[2] Vizagapatam District Manual, p. 154.

gneissose schists is impure; this, coupled with the fact of its position, renders it difficult to suppose that it will ever have any commercial value.

Rajputana: Gurgaon District.—Sohna, Lat. 28° 14′; Long. 77° 7′. A so-called plumbago mine was discovered at this locality by Dr. Thornton in 1861.[1] The graphite occurred in lumps and disseminated through the rock. Mr. Hacket,[2] who visited the spot, describes the deposit as worthless, the quality of the mineral being very inferior.

Afghanistan.—Koh-i-daman.—Captain Drummond[3] states that he obtained a specimen of graphite, said to have been obtained in the vicinity of Koh-i-daman, and he includes it as one of the regular productions of Northern Afghanistan.

North-west Provinces: Kumaun District.—Almora.—In the course of his mineralogical survey of the Himalayas, Captain Herbert,[4] was the first to discover the presence of graphite in the neighbourhood of Almora. He found kidney-shaped lumps, 1 to 3 inches in diameter, lying on the surface of a portion of the ridge which was formed of mica schist. Although somewhat mixed up with the quartz, iron, and mica, it was found to have a specific gravity of only from 2·21 to 2·26, as or 2·7 according to Mr. Prinsep,[5] who gave a rough analysis of it as follows:—

Carbon	71·6
Iron	5·0
Silex	15·
Alumina	8·4
	100·

From a comparison with analyses which he made of Ceylon and English graphites, Mr. Prinsep formed a very favourable opinion of the Himalayan mineral; but it is evident that the sample of English graphite he examined was of very inferior quality, as it contained 36 per cent. of impurities. In the year 1850 Major H. Drummond[6] was placed on special duty by the Governor General for the express purpose of opening up and ascertaining the value of these deposits. As to quantity his operations appear to have sufficiently proved the existence of a large amount, though somewhat scattered, at numerous localities; but the quality

[1] Balfour's Cyclopædia, Art.—Plumbago.
[2] Records, G. S. I., Vol. XIII, p. 249.
[3] Jour., As. Soc., Bengal, Vol. X., p. 92.
[4] As. Res., Vol. XVIII, p. 230; and Jour., As. Soc., Bengal, Vol. XI, p. cxxvii.
[5] Gleanings in Science, Vol. III, p. 280.
[6] Selections from Records, Govt. N. W. P., new series, Vol. III, 1867, p. 371.

appears to have been far removed from the standard sample of Cumberland graphite, with which he had been supplied. Specimens from Balti and Palsimi occurred in tabular form and showed a metallic lustre on being fractured. A sample from Major Drummond, assayed by Mr. H. B. Medlicott, had the following composition :—

Carbon	52·03
Silex, &c., insoluble in strong hydro-chloric acid	2·88
Peroxide of iron and alumina	7·68
Carbonate of line	34·94
Magnesia and loss, &c.	2·47
	100·

Dr. Royle[1] relates that although Captain Herbert himself made some pencils directly from the graphite as it was found, the opinions of several experts, including the principal pencil manufacturers in England, were decidedly against the Kumaun samples having a commercial value. The amount of contained grit being injurious to their machinery they were unwilling to use it, but suggested that a purer material might be obtainable. Mr. Rose, who is quoted by Mr. E. T. Atkinson,[2] examined specimens obtained at Garjoli near Balti and at Palsimi 3 miles east of Almora, and seemed to think that all the samples, even the most impure, could by grinding and washing be deprived of their grit. Dr. Royle speaks of £5 a ton as the value of some of the samples he refers to; but it may be doubted whether that figure could be obtained now, and, supposing that it could, whether it would cover the cost of mining and transport.

Among other notices of this deposit may be mentioned one by Mr. W. Sowerby,[3] though it does not add much to previous knowledge as to its precise nature.

It seems that the graphite is much mixed up with other minerals in the schists, and the numerous attempts to find a workable thickness have not been successful. Indications of its presence are said to extend over a distance of 15 miles. Under the circumstances of quality and position there are no grounds for believing that this graphite can ever be worked so as to become a profitable commercial commodity. The precise spots mentioned by the several authorities are on the Kalimatiya (black-earth) hill to the north of Almora, on the spur of Banini Devi, facing Almora, on the Lohughat road, Garjoli, and Palsimi. It is also

[1] Jour., As. Soc., Bengal, Vol. XXIV, p. 203; and Madras Jour. of Lit. and Sci., Vol. I, new series, p. 257.

[2] Economic Mineralogy of the Hill Districts: Allahabad, 1877.

[3] Sel. Rec., Govt. of India, Vol. XVII, pp. 5 and 8.

found in Patti Lohba in Garhwal on the Karnprayag road, and is stated to be used in that part of the country as a pigment.

Mr. Medlicott[1] describes the deposit as "a band of graphitic schists, regularly associated with the other metamorphic strata of the district. The best lumps of graphite have been found where this schist has been crushed along a fault or line of strain and the graphitic matter has somehow become concentrated in lumps of various size." Both modes of occurrence are described as analogous to those presented by the carbonaceous Infra-krol shales of the Simla region, where coal-mining has been attempted on the bands of concentration. The samples of Kumaun graphite at present in the Geological Museum are very dull looking and deficient in lustre, and from their weight it is probable contain much iron.

Darjiling.—In the year 1852 attention was directed by Captain Sherwill to a supposed deposit of graphite at the foot of the Darjiling hills. The samples forwarded by him to the Asiatic Society were described by Mr. Piddington [2] as being of a very inferior description. Mr. Mallet,[3] who subsequently examined the locality, only goes so far as to apply the term semi-graphite to the substance. He states that the carbon in the highly altered Damuda shales has only been partially changed from the amorphous to the graphitic condition.

Captain Sherwill's specimens and another obtained by Mr. Mallet were assayed by Mr. Hughes, and the percentage of impurities which they were found to contain is just about equal to that of the carbon which, as stated above, ought to be present in good graphite—

Rukte Nadi	92·0 Ash.
Near Pankabari	83· „
Near Kurseong	84·6 „

This ash is mostly silicious. The carbon in these shales is not even all in the condition of graphite. Mr. Mallet recognises the possibility of a better quality being found, but does not look forward with any confidence to its probability.

Burma.—According to Major Strover,[4] graphite is found in Upper Burma to the east of Nat-taik, on a low range of hills near the village of Nzoketoke. It is not utilised. Mr. Doyle [5] states that the late King submitted samples to experts at Mandalay, and the result of the analysis (such as it was) was satisfactory.

[1] Mem., G. S. I., Vol. III, part II, p. 180 (1864).
[2] Jour., As. Soc., Bengal, Vol. XXI, p. 538.
[3] Mem., G. S. I., Vol. XI, p. 64.
[4] Indian Economist, Vol. V, p. 14.
[5] Contribution to Burman Mineralogy: Calcutta, 1879.

Amber.—Within the limits of British India no deposits containing amber in sufficient quantity to be of economic importance are known to exist. Dr. Griffiths,[1] indeed, speaks of its occurrence with the lignite coal at Karaibari, east of Rangpur. But this, as will be seen on a future page, is a friable mineralised resin which is not in the condition of amber. Sir W. Ainslie[2] states that amber of fine quality had been found in the Deccan, but was scarce, and that it was occasionally found also in Travancore. Dr. Balfour suggests that these later cases refer to a substance allied to copal, which is found in the Venkully cliffs in Travancore.[3]

Owing to the word *Ambra,* which means ambergris, being used by German writers, it has been supposed that amber occurs in the Nicobar Islands; but while there is no *à priori* improbability in the tertiary lignite beds of the Nicobars containing amber, the substance collected there appears to be ambergris, consisting of the excreta of certain cetaceans, which is occasionally drifted on to the shores of the islands. Dr. Rink, however, describes a substance which was evidently similar to the Karaibari resin as being found in the lignite of the Nicobars.

The only worked source of amber of any value in the neighbourhood of the limits of British India is the following :—

Burma: Payentoung, Lat. 26° 20′; Long, 96°.—At Payentoung or Payendwen, in the valley of the Hukung or Hookoong, and near the sources of the Kyendwen, there are amber mines which appear to have been worked with varying success for a very long period, and have, it is believed, produced a large quantity of amber which has been disposed of in the markets of Upper Burma and Assam. These mines are sometimes spoken of as the mines of Ava, being included in the territories of the King of Burma. By what name they should be known is somewhat uncertain, as neither of those given above appear on the most recent maps of the region (dated 1875). Possibly the Pon-Kran of this map may be the locality, and Kinto Poung is perhaps the Kotahbhum mentioned below. The latitude given above is on Colonel Yule's authority; the longitude is only approximate. The Rev. Mr. Mason refers to a description of these mines by Dr. Bayfield, but reference to the original work, which is believed to be still in manuscript, is not given; there are, however, several other independent accounts.

In 1835 Colonel Hannay[4] visited the Payentoung or Hukung valley and collected some information regarding the amber. Not only does it occur at Payentoung, but also at Kotahbhum, where it is said to exist in

[1] Private Journal of Travels in India, &c., Calcutta, 1847, p. 77.
[2] Materia Medica, p. 3.
[3] Cyclopædia, Art. Amber.
[4] Jour., As. Soc., Bengal, Vol. VI, p. 270.

great abundance though of inferior quality; but the latter locality is considered sacred by the Singhphus, who therefore do not allow the amber to be removed. The principal traffic in the valley was in amber, a few Chinese, Chinese Shan and Chinese Singphu merchants being in the habit of visiting the spot annually. The common sorts were sold at the rate of Rs. 4 for a seer and a half, but the better qualities were expensive.

A more complete account of the locality is given by Dr. Griffiths, who actually visited the mines in 1837. They are situated on a range of low hills, perhaps 150 feet above the plain of Meinkhun, from which they bear south-west. On the brow of a low hill there were numerous square pits, 4 feet in diameter and of variable depths. The implements used consisted of wooden crowbars tipped with iron, wooden shovels and bark baskets for drawing up the water. Underneath from 15 to 20 feet of red clay containing small pieces of lignite, there is a grey slaty clay, which increases in density with depth, and includes imperfectly formed lignite with which the amber is found very irregularly distributed. No fine specimens were then obtainable. Though much prized as an ornament, the price was not high, a first-rate pair of earrings only costing Rs. 5. The outturn appears to be very variable; in Dr. Griffiths' time the workmen said that for six years they had had no success.

CHAPTER II.

COAL—PEAT—PETROLEUM.

COAL.—General Remarks. *Peninsular Areas*—Madras—Hyderabad—Orissa—Bengal—North of Damuda Valley—Damuda Valley—North-West and West of Damuda Valley—Sone Valley—Mahanadi Valley—Godavari Valley. *Extra-peninsular Areas.* Cutch—Sind—Afghanistan—Punjab—North-West-Himalayas—Sikkim—Assam—Chittagong—British Burma—Upper Burma—Andaman Islands—Nicobar Islands. PEAT.—General Remarks—Madras—Bengal—Oudh—Kashmir—North-West Provinces—Nepal—Assam—Burma. PETROLEUM—General Remarks—Singrowli—Alwar—Cutch—Balochistan—Afghanistan—Punjab—Assam—Burma.

Coal: General Remarks.—In the preceding parts of this work the geological age of the carboniferous deposits of the peninsular and extra-peninsular areas have been fully discussed; and in connection with the descriptions of the various fields a considerable amount of information has been given as to the quality and extent of the coal which is known to exist in them respectively.

Although it may not appear at first sight to be of great importance, from an economic point of view, whether coal, provided of course that it is itself good, belongs to the palæozoic, mesozoic, or kainozoic periods, the actual mode of occurrence is a matter of great importance in the tracing out of coal seams, and this varies with the age of the measures. The practical miner, who coming to India expects to find here the familiar strata of the true carboniferous measures, is destined to be disappointed. Although cases have not been wanting of men who were so wedded to their early ideas that they professed to be able to recognise the individual seams of Lancashire in some of our Indian coal-fields, others have not taken long to realise the difference and modify their methods accordingly.

The rocks which in peninsular India probably correspond, as regards the time of their formation, to the true carboniferous rocks of Europe are not coal-bearing, and the oldest coal measures in this country belong to a period which is well included within the limits of the upper palæozoic or permian and the lower jurassic formations.

All the useful coal of the peninsula may conveniently be described as being of permio-triassic age, and with two exceptions, it may be added,

these measures do not occur beyond the limits of the peninsula. In the extra-peninsular areas, however, we find coal in various younger deposits. In the jurassic rocks of Cutch thin and unimportant seams of coal have been found; and there are also some lignite beds of this age in the Punjab Trans-Indus districts of Bannu and Kohat. The cretaceous rocks of the Garo and Khasi hills include some considerable coal seams of good quality. To this age possibly should be referred the coaly and carbonaceous deposits of parts of Burma and the Andaman and Nicobar Islands, but of these it may be said that so far as anything is certainly known they may really be of lowest tertiary age. Of undoubted lower tertiary, nummulitic, or eocene coals and lignites there are numerous examples which are met with at intervals from Sind, through Afghanistan, the Punjab, at the foot of the Himalayas, in Assam, and in Burma. It is the exception for the coal of this age, in these localities, to occur in such quantity as to possess any real economic value, but very noteworthy exceptions do occur in Assam and Burma. One instance, in peninsular India, of a carbonaceous deposit, which is probably also referable to the eocene period, exists in Travancore. The coal measures of Upper Assam, so far as the slight evidence available goes, are considered to be possibly of miocene age (part II, p. 702); they are almost certainly younger than the seams found at or near the base of the nummulitic rocks elsewhere. In the higher or younger tertiary groups at the base of the Himalayas, although carbonaceous deposits, chiefly in the form of lignite from drift wood, not unfrequently occur, there is no known continuous seam of useful fuel.

In describing the coal-fields from the economic point of view it will be convenient to follow the geographical arrangement adopted with reference to other mineral productions; but in the particular case of coal there is a disadvantage in this method of treatment, as it involves the breaking up of one large tract of coal measures, namely, that in the Godavari Valley and its tributaries, in consequence of its spreading over an area, portions of which belong to Madras, Hyderabad, and the Central Provinces respectively.

Some years ago, Mr. Hughes[1] estimated the areas in India in which coal measures occur, including those in which they are believed to exist underneath younger formations, as amounting to a total of 35,000 square miles. This is a liberal calculation which is not likely to be increased by any discoveries which may be made hereafter, though it may sustain diminution when the boundaries are more accurately ascertained in the cases of some of the less known fields. To prevent any

[1] Records, G. S. I., Vol. VI, p. 65.

misconception, however, it is necessary to state that in some parts of the basins, supposing the coal measures do exist, the thickness of the younger overlying formations is so great that the working of the coal cannot, in reference to present systems of mining, be contemplated as being even remotely possible.

The several basins have the following areas allotted to them by Mr. Hughes:—

	Square miles.
Godavari and affluents	11,000
Sone	8,000
Sarguja and Orissa	4,500
Assam	3,000
Narbada and affluents	3,500
Damuda	2,000
Rajmahal area	300
Unsurveyed, &c.	2,700
	35,000

Although the coal-mining industry has now been in operation in India for more than a century, and although there has been a steady increase in production and consumption, which has been especially notable in the last decade, still it must be stated that the development of the coal resources of the country is as yet in a very imperfect condition. Out of upwards of thirty distinct fields in peninsular India only four or five are worked at all, and of these only two have arrived at such a condition that, although the actual mines are numerous, they can raise from 1,000 to 2,000 tons a day. In the extra-peninsular areas mining is not established anywhere regularly, though it shortly will be, there is reason to believe, in Assam.

The reason for this state of things is not far to seek. Most of the coal-fields are too remote from the ports and the centres of manufacturing industry to render it possible that their coal can be carried to places where it would have to compete with the better qualities of fuel brought from Europe. With the extension of lines of railway into the central parts of India some of these fields may be opened up hereafter, and the increased facilities for carriage may render it possible to establish factories for the reduction of metallic ores and other purposes which would increase the demand for coal.

Before treating of the actual present compared with the past consumption of coal in India, it will be well first to describe its quality or rather its qualities, for it varies a good deal, as will be seen from the details given below, in reference to the different fields.

In general the coal of peninsular India may be described as a laminated bituminous coal, in which dull and bright layers alternate. Much of it does not cake freely, while a not inconsiderable proportion will not do so at all. However, from the coal of particular seams in the Raniganj, but more especially in the Karharbari field, fairly good qualities of coke can be made. In the Raniganj field the best coke has been made from the Sanktoria coal. The percentage of ash in coal which is brought to market averages from 10 to 15 per cent., that is to say that coal with less than 10 per cent. of ash does not commonly occur, and coal with more than 15 per cent. does not, as a rule, find a ready sale. Exceptions to the former occur in the case of the seams at Sanpur and Bamandiha, in the Raniganj field, where the percentages of ash are only 8·7 and 8·9.[1]

As regards the proportion of fixed carbon which is the most important factor in the production of heat, the average in the Raniganj field is under 55 per cent., while in the Karharbari field it is probably about 10 per cent. higher. There is no case of a true anthracite having been discovered in any of these fields; but the crushed and powdered coal at the foot of the Darjiling Himalayas, which has been described by Mr. Mallet[2] approximates in character to anthracite on account of the removal of its original volatile constituents.

The moisture or hygrometic water varies a good deal in the coals from the different fields. In those of the Godavari and Wardha areas it is exceptionally high, being often 14 per cent., while in the Raniganj field the average is not more than 4·8 per cent.

The quantity of sulphur and phosphorus is very variable in different seams, and though often large, coal sufficiently free from these impurities is to be found for the manufacture of iron and steel, especially if the newest processes are applied. To this subject reference will again be made in the chapter on iron. The average of 31 assays of coals from Raniganj by Mr. Tween gave sulphuric acid 0·44 per cent. and phosphoric acid 0·83 per cent.

The characteristics of the coals of the extra-peninsular areas are so variable that they must be described under their separate headings below. Generally speaking, the tertiary coals are bright and jetty and non-laminated, and they are more bituminous than the coals of the peninsular fields; many of them are extremely friable and susceptible to disintegration under exposure; they do not cake as a rule and the proportion of ash is small.

[1] Hughes. Records, G. S. I., Vol. VII, p. 21.
[2] Mem., G. S. I., Vol. XI.

Table showing the coal imported into and raised in India for the years from 1852 to 1880 inclusive.

Years.	Imports.	Bengal Fields. Raniganj.	Bengal Fields. Karharbari.	Bengal Fields. Total.	Central Provinces Fields. Warora.	Central Provinces Fields. Mopani.	Central Provinces Fields. Total.	Total consumption.
1852-53 .	43,562							
1853-54 .	58,410							
1854-55 .	41,987							
1855-56 .	76,712							
1856-57 .	82,078							
1857-58 .	92,983	......	......	293,443	... ..	......	......	386,426
1858-59 .	99,701	......	......	......	......	......	......	...
1859-60 .	74,263*a*	368,960	......	368,960	......	......	......	413,223
1860-61 .	...	373,633	......	373,633	......	......	......	...
1861-62 .	174,862*b*	288,336	......	288,336	......	......	......	463,198
1862-63 .	122,722	319,660	......	319,660	......	......	......	442,382
1863-64 .	189,611	352,036	......	352,036	......	......	......	541,647
1864-65 .	216,985	334,533	......	334,533	......	......	......	551,518
1865-66 .	228,319	326,312	... ..	326,312	......	......	......	554,631
1866-67 .	257,652*c*	399,630	......	399,630	......	......	......	657,282
1867-68 .	368,618	423,034	......	423,034	......	......	......	791,652
1868-69 .	332,718	467,626	......	467,626	......	......	......	800,344
1869-70 .	315,935	......	......	431,828	......	......	......	747,763
1870-71 .	269,396	369,131	30,000	399,431	......	78	78	668,905
1871-72 .	361,960	284,623	37,820	322,443	......	5,947	5,947	690,350
1872-73 .	310,265	......	70,000	......	......	7,332	7,332	...
1873-74 .	354,231	......	......	......	......	9,451	9,454	...
1874-75 .	360,251	......	......	......	54	15,107	15,161	...
1875-76 .	388,480	467,924	......	......	11	19,170	19,181	...
1876-77 .	523,384	467,924 Average.	......	......	1,089	13,912	15,001	...
1877-78 .	603,731	467,924	308,386	776,310	28,446	12,972	41,418	1,421,459
1878-79 .	473,027	523,097	381,173	904,270	35,924	10,384	46,308	1,423,605
1879-80 .	587,634	469,699	362,844	832,543	25,078	10,618	35,696	1,455,873
1880-81 .	618,720*a*	......	......	......	16,039	9,401	25,440	.
			......	......	106,641	114,375	221,016	

Hughes. Records, G. S. I., Vol. XII. (*a*) Doubtful. (*b*) Incomplete for Bengal. (*c*) For eleven months only.

[1] From Appendix to Financial Statement "Government Gazette" 1880-81. (*a*) For eleven months only.

[3] From Dr. Oldham's Coal Resources and Production of India; Calendar years.

[4] From Bengal Administration Reports.

[5] From return of coal carried by Great Indian Peninsula Railway these figures do not agree with the actual output. Moreover they refer to the calendar years not to the official, as do the returns from Bengal.

In the preceding table an attempt has been made to represent the actual consumption of coal in India, but, as will be seen by the foot-notes, the figures are culled from various sources and are not by any means, of equal degrees of authenticity. As separate statistics of coke and patent fuel imports are not available for all the years they have been omitted, but if to the totals given in the last column, for the last few years, an average of 50,000 tons be added to cover these imports, and to cover all the coal raised in outlying fields, regarding which there are no statistics, we shall arrive at the conclusion that the total present amount of mineral fuel consumed in India is 1,500,000 tons per annum, of which one million is raised in the country and half a million is imported. In Appendix A. will be found a statement of the coal and coke imports for the years from 1867 to 1880. It will be observed that there are discrepancies in some cases, the totals of coal and coke being actually less than the total for coal alone in the above table; but for these an explanation will be given.

The price of European coal at Indian ports varies from time to time as might be expected, the causes for fluctuation being so obvious as not to need special indication. In the last financial statement issued by the Government of India the average value per ton of European coal at the Indian ports for the past five years was given as follows: 1876-77, Rs. 17-15-6; 1877-78, Rs. 16-9-8; 1878-79, Rs. 18-13-9; 1879-80, Rs. 19-2-3; 1880-81, Rs. 18-1-10. Taking the average of these again the cost has been Rs. 18-2-1, which put into English money, at an exchange of 1*s*. 8*d*. per rupee, would be £1-10 per ton. Although the price has often been higher it has on occasions been very much lower: thus in the year 1871-72 English coal was sold in Calcutta for from Rs. 8 to 9 per ton, or about half the above amount. Strangely enough it is stated[1] that the high price of coal in England in 1872 had no effect on the Calcutta market.

Australian coal has been imported since 1857, but the amount has fluctuated much from year to year: in 1858, 14,061 tons went to Bengal and 8,998 to Bombay. In 1874, 14,677 went to Bengal and apparently none to Bombay. In 1877 only 799 tons went to Bengal and none to Bombay. In 1879-80 the total imports rose to 49,128 tons.

English coal, it may perhaps be said, except under exceptional demand, could not command a higher price at the principal ports than about £2 a ton.

The price of Indian coal at the pit's mouth varies a good deal in the different fields; thus coal which, in Raniganj, might be obtained perhaps

[1] Bengal Administration Report, 1872-73, p. 228.

for Rs. 2-8 to Rs. 3 a ton costs about Rs. 10 at Mopani. To the prime cost at the mines must be added the cost of carriage at the rate of $\frac{1}{6}$th pie *per* maund per mile, or Rs. 2-5 per ton per 100 miles, in order to obtain the value of country coal at towns situated on the Railway. On the Jabalpur branch of the East Indian Railway, in 1878, the average cost of coal from the Company's mines at Karharbari was £1-2-4$\frac{3}{4}$ per ton. Further down the line to Bombay, on the Great Indian Peninsula Railway, there is an oscillating point where sea-borne English coal meets Bengal coal at equal rates, the amount of work each can do being taken into consideration.

In Madras, according to a table quoted below, the price of Karharbari coal is Rs. 27-4 per ton, Raniganj costing Rs. 20-3-5 per ton. Until they can be put down at the Railway station there at about one-fourth less respectively they will not be able to compete with imported patent fuel, which, while it costs only a little over Rs. 22 a ton, has a much higher working power.

On many of the lines in Upper India wood fuel is largely employed, being much cheaper than coal, upon which freight for perhaps 1,000 miles or upwards has been paid.

In the account of the Raniganj field below there will be found a brief sketch of the method of coal-mining in practice there. In some cases it appears to have been excogitated by the early pioneers, to whom the systems of coal-mining in practice in Europe were unknown; and the methods then adopted for bringing the coal to bank are tenaciously held to by the native miners, with whom the trade has become hereditary. Such people are averse to innovation and are ready to strike when a qualified manager endeavours to introduce some system to replace any old custom. Steady though gradual progress is, however, being made in this direction; but it is still the case that in the oldest, largest, and most valuable field in India the system of mining is far behind those in practice in the other fields, where everything had to be commenced and the labour educated *de novo* within the last decade. In the latter cases trained engineers have entered upon almost virgin fields, and have with more or less success commenced operations in a legitimate manner without leaving the evil consequences of bad and destructive work to those who may have to follow them.

Any one is capable of setting a party of coolies to delve and hack away at an exposed outcrop of coal. Of course the coal so taken out is at first easily got and at a low rate of expenditure, and this is sometimes regarded as being economical coal-mining. It would be impossible to

[2] T. W. H. Hughes, Records, G. S. I., Vol. XII, p. 83.

offer any estimate of the amount of injury which was thus done to valuable seams in the early days of the industry.

At both the Bengal fields labour is abundant, but in those of the Central Provinces it is often insufficient. Accidents, particularly those accompanied by loss of life, are of rare occurrence; but a single fatal accident, especially if it take place under-ground, is apt to cause a general scare and stampede, and there is no doubt that were it not that they are so, and that the miners are as a rule fairly and justly dealt with by those over them, labour, which is now plentiful, would become very difficult to obtain.

Plate No. II represents a 'gin' in which women supply the motive power. At the principal mines, especially at Karharbari, these gins are speedily being replaced by suitable hauling engines, but though destined to become extinct there are not a few of them still in the Raniganj field.

The following list gives the names of all the separate coal-fields which are known to exist in India, and the respective basins or valleys in which they occur:—

Peninsular Coal-fields.

Madras.

Beddadanol	
Madaveram or Damercherla	
Lingalla	

Hyderabad or Nizam's territory.

Kunnigiri	
Singareni	Wardha and Godavari Valleys. Several of these are merely outcrops of Barakur or coal measure rocks on the margins of the Gondwana basin, and perhaps should scarcely be called fields.
Alapalli	
Kamaram	
Bundella	
Chinur	
Tundur	
Aksapur	
Antargaon	
(Sasti)	

Orissa.

Talchir	Brahmini Valley.

Bengal.

Rajmahal Hills include five semi-detached fields	
Jainti	
Sahajori	North of the Damuda Valley.
Kundit Kuriah	
Karharbari	

Raniganj	
Jharia	
Bokaro	Damuda Valley.
Ramgarh	
Karanpura, North	
Ditto, South	
Chope	
Itkuri	North-west and west of Damuda Valley.
Aurunga	
Hutar	
Daltonganj	
Tattapani	
Irea	
Morne	
Singrowli	
Sohagpur	Valleys of the Sone and tributaries.
Jhilmilli	
Bisrampur	
Lakhanpur	
Rampur	
Central Provinces.	
Raigarh and Hingir	Mahanadi Valley.
Udaipur and Korba	
Mopani	
Shapur or Betul	Satpura Basin.
Pench	
Wardha	
a. Bandar	
b. Warora	
c. Ghugus	
d. Wun	Wardha and Godavari Valleys.
e. Between Wun and Papur	
f. Junara and Chicholi	
g. Sasti	
h. Paoni	

Madras.—To the great importance which an accessible supply of good coal would possess in Madras is no doubt to be attributed the number of discoveries in that part of India of so-called coal seams, which on investigation by qualified experts have in most cases proved to be something very different from what the enthusiasm of the discoverers led them to believe. These discoveries which were calculated to and did stimulate the interest of the Government and the public gave rise to a large amount of literature, whether in the form of original descriptions, with the speculations dependent thereon, or of subsequent correspondence. As this literature still exists it is only right that it should be noticed here. The statements made in one volume must be placed side

by side with their refutation in others. If this were not done the former might be a cause of trouble and confusion in the future when all memory of the refutation had passed away. As a rule the extravagant speculations of enthusiasts find a more ready circulation than do the more matter of fact and often less sanguine opinions of experts.

As evidence of the thoroughness with which search has been made in the Madras Presidency the following are not without their value. It would surprise and amuse the reader were a list made of all the heterogeneous substances whose presence has been stated to afford "favourable indications" of the presence of coal.

Malabar: Bepur or Beypoor, Lat. 11° 10′; Long. 75° 53′.—A carbonaceous deposit, which was discovered at several points along the Malabar coast by Captain Newbold[1] and General Cullen,[2] having given rise to a supposition that coal might be found close by, may be most conveniently described here.

The first exposure of this bed described by Captain Newbold was seen in the bank of the Bepur river within the range of the tide. It was a lenticular mass varying in thickness from 5 feet down to 2 inches. Portions were laminated and earthy; others seemed to consist wholly of carbonized woody matter; the colour varied from greenish to jet black. In places shells were imbedded. The further description mentions carbonized trunks and branches eroded and projecting from the mass. Similar deposits were met with at Vorkully or Warkilly, 15 miles south of Quilon, in the banks of the Tutalla river, in South Malabar and between Paulghaut and Calicut. The bed at Quilon, which had a lenticular shape, was stated by General Cullen to be included in laterite which rests on gneiss. This locality has been recently examined by Mr. King, who has found that the lignite occurs with tertiary sandstones and alum shales which he thinks are probably of the same age as the Cuddalore sandstones. There appears to be no prospect of these deposits yielding a large amount of fuel.

Mysore.—Dr. Hunter,[3] Superintendent of the School of Arts, Madras, described as coal a substance received from Dr. Orr, of Bangalore, which he says was poor shaly stuff, and which burnt feebly, emitting a bituminous smell, but did not catch fire; it was in thin layers not more than from half an inch to three-fourths of an inch thick. It was coloured green with chlorite, and the fact of its being in very small pieces and associated with what is called a true transition conglomerate, very rich

[1] Madras Jour. of Lit. and Sci., Vol. XI, p. 239.
[2] *Op. et* vol. *cit.*, p. 242.
[3] Indian Economist, II, p. 210.

both in iron and manganese, was apparently considered to be a good 'indication.' This coal does not appear to have attached so much notice as some of the other 'discoveries' noted below.

Bellary.—Near the Yerragoody hill samples of coal were discovered by Dr. Hunter in 1871, and the Madras Government were strongly urged to have borings made in order to win the seam from which they were supposed to have come. Before this was done Mr. Foote[1] was deputed to examine the actual spot where the coal had been picked up. He found the prevailing rocks were granitic gneiss traversed by trap, and he demonstrated most clearly that the coal must have either dropped off a passing cart or have been carried by some other means from a depôt of English coal on the railway, 3 miles off.

Nellore.—Mr. G. Powell[2] in 1857 discovered in four different spots in the Caligherry taluk a substance which he states has such a strong similitude to coal that he "takes the liberty of calling it coal," and the places where he obtained it in quantities 'seams;' notwithstanding his matter-of-fact account of its mode of occurrence his samples proved, on examination by Mr. Wall, to be simply fragments of schorl,[3] but they did include one combustible substance which Mr. Wall stated to be asphalt, but it appeared to have no history. Some real coal that had previously been found here by Mr. Powell, Mr. Wall concluded had been carried there by accident. A piece of lignite from the alluvium in the Tada taluk had been shown to Mr. Wall by Dr. Hunter.

Kadapah.—Dr. Hunter in the year 1871 brought to the notice of the Madras Government the opinion of a Mr. Adams, a practical coal-miner, that there were good indications of coal at a spot 5 miles north-north-west of Kadapah, where the limestones of the Karnul series have been quarried. The locality was visited by Mr. Foote,[4] who failed to find the faintest trace of any carbonaceous matter in the rocks.

Kistna District: Jugiapetta.—In the year 1851 Colonel Applegarth was impressed with the idea that the rocks of Jugiapetta contained coal, and having made several small sinkings a substance was brought to him by those whom he employed which supported combustion; much correspondence ensued, and at last, in January 1868, the locality was visited by Dr. Oldham, who was accompanied by Colonel Applegarth and Mr. Sturt, Acting Head Assistant of the district, who had already endeavoured, without success, to find traces justifying a belief in the existence of a coal-field.

[1] Records, G. S. I., Vol. IV, p. 16.
[2] Madras Jour. of Lit. and Sci., Vol. XVIII, p. 291.
[3] Conf. King, W., Records, G. S. I., Vol. VII, p. 160.
[4] Records, G. S. I., Vol. VI, p. 17.

After careful examination, Dr. Oldham was compelled to report[1] that there were no grounds whatever for hope that coal would be found in the area. The rocks, without exception, belonged to formations long anterior to the coal-bearing rocks of India, and their lithological and metamorphosed characters were wholly inconsistent with the idea of coal occurring with them. There was, moreover, no more reason for coal occurring there than in any other part of the districts where the same rocks are found.

The Government of Madras accepted with regret the fact that Dr. Oldham's exploration and report had proved 'beyond all doubt' the non-existence of coal in the valley of the Kistna.

But the matter was not allowed to drop. Colonel Applegarth again and again addressed the Government on the subject, and published letters in English and Indian newspapers, insisting upon the existence of a coal-field where the subsequently published geological report by Messrs. King[2] and Foote[3] showed it absolutely impossible that coal measures were ever found. At length, in the year 1874, on the suggestion of Mr. H. B. Medlicott, then Officiating Superintendent of the Geological Survey of India, the Government of India addressed a letter to the Government of Madras, proposing that Mr. Vanstavern, then engaged on borings in the Beddadanol field, should be directed to set the matter finally at rest by making borings at points indicated by Colonel Applegarth with his own hand on his own map.

In April 1875 Mr. Vanstavern supplied sections showing the rocks passed through in 11 borings at the indicated localities at Raveralu and Vadadey. These borings, it is perhaps almost needless to remark, did not prove the presence of any rocks younger than those seen at the surface, nor did they encounter any rock resembling coal. Phœnix-like this matter will possibly again rise under the fostering care of some enthusiast who may meet with the early positive statements. It is for this reason alone that so many lines have been devoted to the subject here.

Having thus pointed out certain localities where coal does *not* occur within the limits of the Madras Presidency, it is now necessary to pass to the description of those where it does. Although there is an extensive tract of Kamthi rocks, which may overlie coal measures in the Godavari valley, there are only a few points on its margins where they actually crop out, and as yet it is not known how far they may extend underneath, nor at what depths the coal would be found if deep borings

[1] Proceedings, Madras Government, Revenue Department, 5th March 1868.

[2] Mem., G. S. I., Vol. VIII.

[3] Special memorandum on the subject by Mr. Foote, Department of Agriculture, Revenue, and Commerce, 1874.

were undertaken. These outcrops are at Bedadanol, Madavaram (or Damercherla), and at Lingalla.

BEDDADANOL, Lat. 17° 14′; Long. 81° 17′ 30″.—This field, which is about 5¼ square miles in extent, is situated about 38 miles west-north-west of Rajamahendri. It was first discovered by Mr. W. T. Blanford[1] in 1871. Subsequently, in 1875, it was visited by Mr. King,[2] who gives further details as to the strata which are exposed. No coal was seen, but the sandstones presented a strong resemblance to those of the Singareni field. Borings made here by Mr. Vanstavern in 1874 fully bore out the prediction that this was an area of coal measures, as four seams were struck, the largest being 4½ feet thick and at a depth of 188 feet 4 inches from the surface. But the quality of the coal, as indicated by analyses made by Mr. Tween, showed that it was excessively poor stuff and perfectly worthless as fuel. This is a most unfortunate fact, as the discovery was the first genuine one which had been made in the Madras Presidency.

The analyses were as follows:—

	Average.		Picked.	
	Coal.	Coke.	Coal.	Coke.
Carbon	16·4	22·5	37·0	59·5
Volatile	30·6	...	37·8	...
Ash	53·0	77·5	25·2	40·5
	100·0	100·0	100·0	100·0

It seems to be still possible, however, that borings to the deep, within the margin of the overlying Kamthi rocks, may prove coal of better quality and greater thickness. The coal proved, it should be remembered, was in all probability near the original edge of the deposit, where it might easily be less pure and less thick than nearer to the centre of the basin.

DAMERCHERLA (OR MADAVARAM), Lat. 17° 36′; Long. 81° 7″.—The most important portion of this field being included on the Nizam's side of the river Godavari, it will be described below. The amount of coal on the British side is considered by Mr. Blanford not to exceed 25,000 tons.

LINGALLA, Lat. 18°; Long. 80° 54′.—In the small area of Barakar or coal-measure rocks surrounding Lingalla, two seams, neither of them exceeding 2 feet in thickness, were found by Mr. Blanford[3] in

[1] Records, G. S. I., Vol. IV, p. 49.
[2] *Idem*, Vol. V, p. 112, and Vol. VII, p. 159.
[3] Records, G. S. I., Vol. IV, p. 59.

the bank of the Godavari, and another 5 feet thick in its bed. A boring put down to test the extension of this bed inland was unsuccessful.

In the year 1880, officers in the Nizam's service were engaged, according to Mr. King,[1] in making borings to test the field on the western side of the river, but with what results is not at present known.

As the coal found on the British side is of poor quality, and as it would be difficult to work these beds under the bed of the river, even if they were of better quality, the field is not of much value.

Hyderabad or Nizam's Territory.—Although in Part I of this work the coal-bearing rocks of the valleys of the Godavari river and its tributaries have been treated as a whole without special reference to territorial boundaries, in this economic account it has been thought to be advisable to group the actual coal-fields according to the territories in which they respectively occur. It is for this reason that the coal-fields of this tract are disassociated from one another under the headings of Madras, Hyderabad, and Central Provinces with Berar.

Within the limits of the Nizam's territory coal-bearing Barakar rocks are found in the following localities proceeding from south to north: Kunnigiri, Madavaram or Damercherla, Singareni, Alapalli, Kamaram, Bundella, Chinur (or Sandrapali), Tandur, Aksapur, Antargaon and Sasti.

These localities, with the exception of Alapalli, are all situated on or beyond the margins of a tract of Kamthi rocks, which doubtless overlie coal measures, but to what extent is not yet known. It can only be determined by deep borings. Mr. King's[1] recently published memoir contains the latest information on the subject.

Kunnigiri or Kanigheri.—This is a small tract of Barakar rocks, which extends for a distance of about 6 miles at the salient angle of the lower Godavari basin, 25 miles south-west by west of Bhadrachellum. No coal has yet been found, but the presence of the coal-measure rocks is of great importance with reference to future exploration by boring.

Madavaram or Damercherla, Lat. 17° 36'; Long. 81° 7.'—This small field is situated in the bed of the Godavari below Bhadrachellam, extending thence for a short distance on either side into British and the Nizam's territory respectively. It was first reported upon by Mr. W. T. Blanford[2] in 1871, by whom it was estimated that on the British side, as above stated, there are 25,000 tons of coal, of which perhaps only half are available on account of the great admixture of

[1] Mem., G. S. I., Vol. XIX, Part I.
[2] Records, G. S. I., Vol. IV, p. 59.

shale. Under the orders of His Grace the Duke of Buckingham a shaft was sunk to a depth of 56 feet last year (1880); but the work is now at a stand-still.

In the bed of the river on the Nizam's side a series of 14 borings were suggested by Mr. Blanford, but after six had been carried out operations ceased in consequence of representations made by the Nizam's Government. In 1874, according to Mr. King,[1] some borings were made by the Nizam's officers in an area 3 miles from the village of Ryagoodium, and 5 miles south of the Godavari. Three seams of coal were discovered as follows: (1) One foot thick at 247 feet from surface; (2) four feet thick at 272 feet; (3) six feet thick at 314 feet. The quality of the coal appears to have been somewhat inferior. For a fuller account of this field reference should be made to the papers quoted.

Singareni.—This field is situated near the village of Singareni, lat. 17° 30′ 30″; long. 80° 20′, in the Hyderabad territory, about 30 miles to the south-east of the Kamaram field. Its area is 19 square miles, the coal measures being found throughout about 8 square miles. The groups represented are Kamthis, Barakars and Talchirs. One coal seam was originally discovered, but being much concealed its thickness was not ascertained; an assay of a sample from it gave result A—

	A.	B.
Fixed carbon	62·4	66·0
Volatile	22·6	23·0
Moisture (6)		
Ash	15·	11·
	100·	100·

Four seams have since been proved by boring. Their thicknesses are respectively 6, 3, 3, and 34 feet. The last is said to consist of solid coal; an assay of a sample yielded the result given above under B.

This field may possibly become of some economic importance, as there is some prospect of there being a railway constructed at no great distance from it, from Hyderabad to Bezwada.

Already 300 tons of coal from it have been carted to Hyderabad, where it was found to answer well both for smithy purposes and in stationary engines. It has also been tried on the Madras Railway, but at present cost it cannot compete with patent fuel there. It was found, however, to be a serviceable fuel. For a full account of the trial reference should be made to Mr. King's report.[1]

[1] Mem., G. S. I., Vol. XIX, Part 1.

Patent fuel is at present used on the Madras Railway at a cost of Rs. 22-11-9 per ton. The following table received by Mr. King from Colonel Sankey, C.B., Chief Engineer to the Madras Government, will show at what cost coal from different fields must be laid down in Madras in order to compete with this fuel:—

Karharbari coal costs at Madras Rs.	27	4	0;	should cost only Rs.	19	2	0
Barakar " " " "	21	0	0	" " "	16	7	0
Ditto " " " "	22	12	0	" " "	16	3	0
Raniganj " " " "	20	3	5	" " "	14	13	0
Singareni (trial) " " "	29	7	5	" " "	15	4	0

The Raniganj coal used in this trial cannot have been even of average quality. According to Mr. J. Blackburn coal costing Rs. 10 a ton loaded in Calcutta can now be delivered into carts in Madras for Rs. 20-4-6.

Alapalli, Lat. 17° 50′; Long. 81° 32′. Mr. Blanford[1] describes the discovery of fragments in the Kinarswami stream, a tributary of the Godavari, near a village called Alapalli, 30 miles south-west of Dumagudam. The rocks seen there seemed to be Barakars, but no seam was found, though a concealed outcrop may exist under the sand.

Kamaram,[2] Lat. 18° 5′; Long. 80° 14′.—This name has been given to two small fields situated near the village of Kamaram, which lies 40 miles a little north of east from Warangul, in the Hyderabad territory.

The larger one is 6 miles long by about 1 mile broad; it consists of Talchir, Barakar, and Kamthi rocks. It includes two coal seams of fair coal, measuring respectively 9 feet and 6 feet. The available coal is estimated at 1,132,560 tons, and it is stated to be equal to the average coal of the Wardha fields. Its position is unfavourable to its development, water carriage being too far distant. The smaller field, which is about half a square mile in area, is believed to be of no importance.

Chinur, Lat. 18° 50′ 30″; Long. 79° 52′.—A narrow outcrop of Barakar coal measures between the village of Chinur and Sandrapali was discovered by Mr. Hughes.[3] The total thickness of the beds is 200 feet; no outcrop of coal is disclosed, but large fragments of coal which had been carried into the Godavari by the Sandrapali stream were found. Mr. Hughes is of opinion that a boring on the right bank of the Godavari below the point where the stream joins it will strike coal at no great depth. He alludes to the old operations in connection with the supposed occurrence of coal at Kota,[4] 4 miles north of the Godavari.

[1] Records, G. S. I., Vol. IV, p. 82.
[2] King, W. Records, G. S. I., Vol. V, p. 60; and Mem., G. S. I., Vol. XIX, Part 1.
[3] Records, G. S. I., Vol. XI, p. 22.
[4] Walker, Dr. Madras Jour. of Lit. and Sci. Vol., XVII, p. 261, and Vol. XVIII, p. 261.

Tandur, Lat. 19° 9′; Long. 79° 30′.—As being about the centre of a strip of Barakar rocks, which extends from Kairgura to Aksapali, the village of Tandur may be used to indicate the position. It contains one seam of 15 feet, most of which is coal and much of that of fair quality. Mr. Hughes (*l. c.*) traced this seam with varying thickness as far as the Yuloti river, where the dip is 11° to north 20° east. To test its further extension southwards borings are recommended.

Aksapur, Lat. 19° 21′; Long. 79° 28′.—Between Kasni and Aksapur there is a small exposure of Barakars, but no coal is yet known to exist.

Antargaon, Lat. 19° 32′ 30″; Long. 79° 33.′—South of Antargaon the Barakar rocks, according to Mr. Hughes, include a seam of about 6 feet, of which 9 inches is shale. The following analyses are from this locality and from the above-mentioned Kairgura seam:—

	Kairgura.	Antargaon.
Carbon	45·6	51·26
Volatile	42·2	28·25
Ash	12·2	20·49
	100.	100·
Moisture	9·4	8·7

Mr. Hughes states that the Antargaon samples were from the surface; they may therefore, perhaps, not give a fair indication of the quality of the coal. Both coals include a large proportion of moisture, which is a common characteristic of the coal in these fields.

Sasti.—The coal of Sasti and Paoni will be referred to again in the account of the Chanda field, although it is in Hyderabad territory. One seam of 50 feet has been proved. It contains a considerable proportion of good coal from which fair results were obtained in a trial at Bombay. Mr. Hughes estimates the area to be 1½ square miles. Mining operations were carried on here by the Nizam's officers from 1871 to 1874.

Orissa: Talchir.[1]—The Talchir coal-field is situated in the valley of the Brahmini, which may be regarded as a tributary of the Mahanadi, since it anastomoses with it in the conjoined deltas. The area is about 700 square miles in extent. The groups represented have the following estimated thicknesses: Mahadeva, 1,500 to 2,000 feet; Kamthi and Barakar, about 1,800 feet; Talchir, 500 feet. The Talchir group received its name from this locality, a Native State, where it was first discriminated.

The coal is of inferior quality; one large seam at Gopalpersad is largely made up of carbonaceous shale, being similar to that to be

[1] Blanford and Theobald. Mem., G. S. I., Vol. I, pp. 33, 38; Ball. Records, G. S. I., Vol. X, pp. 170, 173.

described as occurring in Hingir. In assays which have been made of fair samples of the coal from the two principal seams at Patrapara, the fixed carbon did not exceed 30 per cent., while the proportion of ash ranged from 30 to over 40 per cent. In a practical trial at Cuttack of some of the Gopalpersad coal there was a residue of 34 per cent. of ash and clinker. The demand for coal in Orissa is too limited to render it probable that under present conditions of communication the field will ever be of much value.

Further to the south-east, partly in the Athgarh State and crossing the river not far from the town of Cuttack, there is an area of sandstones and conglomerates in which fossil plants of the Rajmahal group occur. It was at one time thought that these might overlie coal measures, but there is no sign of the characteristic coal measures anywhere on the margin of the deposits. Some black shales seen near Naraj encouraged the idea that coal would be found, but these really belong to the non-coal-bearing Rajmahal group.

Bengal: Midnapur.—Among the cases of supposed discoveries of coal, descriptions of which are given in these pages, one which had for its scene the jail grounds of Midnapur, is distinguished by its having been a deliberate and cleverly conducted attempt to deceive the public.

During the sinking of a boring for an artesian well in the Central Jail at Midnapur in the year 1869, a European convict who was placed in charge of the work, first as a prisoner and afterwards, when his time had expired, as a free man, expressed a confident opinion that if the boring were carried on beyond the depth of 118 feet, where a second water-bearing stratum had been found, then coal would be struck. Proof of the correctness of these predictions was soon forthcoming, for at 121 feet it was announced that a coal seam had been reached, and at a depth of 130 feet it was believed that the seam still continued. Samples of the coal on being analysed gave excellent results, and much interest was excited by what appeared to be so important and valuable a discovery. Orders were issued to test the extent and dip of the seam by additional borings, and new boring tools were ordered by telegram from England. These were put down and operations were continued with varying and most unexpected results which it is needless to detail.

The operations which were at first conducted independently of the Superintendent of the Geological Survey, were subsequently carried on in communication with him. There being no *a priori* argument against the possibility of coal being found under the alluvium and laterite of Midnapur, the Executive Engineer, who initiated the operations, was advised as to the best method of testing the matter thoroughly. There would be no

object attained by giving here a *precis* of the pile of correspondence existing with reference to this matter; it will be sufficient to state that on the bore holes being subjected to a careful watch the coal ceased to appear, and shortly afterwards, in December 1870, the ex-convict absconded, and on his house being broken into, prepared coal was found as well as large lumps, and it was completely established that all the coal which had been brought up by the boring tools had been first put down, and that 12 months of labour and not a little expense had been caused by the cunning and deception which had been practised by this man. The subsequent proof, to the satisfaction of the authorities, that there never had been a coal seam, was not obtained without a further expenditure of time.

CALCUTTA.—The fact that coal was once obtained at a considerable depth below Calcutta, though perhaps of more scientific than economic or practical importance, is certainly worthy of record here, and it is so, if for no other reason, because this opportunity should be availed of for detailing the actual circumstances connected with the discovery.

In the year 1837, during some boring operations in Fort William, several fragments of coal were brought up by the borer from a depth of 392 feet. These were forwarded to the Asiatic Society by Colonel McLeod, the Chief Engineer.[1]

The coal had a specific gravity of 1·20, and was of fine quality, resembling specimens from Assam rather than those from Bengal. The fragments were rolled and had evidently travelled from some distance. Mr. Prinsep's[2] assay of this coal was as follows:—

Carbon	35·1
Volatile matter	59·2
Ash	5·7
	100·

It was therefore a very light bituminous coal, which may have come from a far distant source.

RAJMAHAL HILLS.[3]—The Rajmahal hills form a series of low plateaus, which are situated at the point where the Ganges turns southwards to form the head of its delta.

The formations in this area, which are connected with the coal measures, are in descending order as follows:—1. Laterite; 2. Rajmahal group, consisting chiefly of contemporaneous traps, with beds of shale, &c., containing fossils plants, 1,500 feet; 3. Dubrajpur group (=Mahadevas),

[1] Jour., As. Soc., Bengal, Vol. VI, p. 709; Corbyn's Indian Review, Vol. II, p. 418.
[2] *Idem*, Vol. VII, p. 198.
[3] Mem., G. S. I., Vol. XIII, Part I.

450 feet; Barakar group (coal measures); 5. Talchir. The whole cover a total area of about 4,000 square miles, but the coal measures are exposed over only 70 square miles; they doubtless extend, however, over a vastly greater area underneath younger formations. Separated by these overlying rocks five distinct areas or fields may be enumerated; 1. Hura; 2. Chaparbhita; 3. Pachwara; 4. Mhowagurhi; 5. Brahmini. These are all on the western margin of the hills. There is no continuity between the seams of these areas, and estimates as to the amount of coal could only be made on the vaguest and most imperfect data. It will be an interesting and economically important point to decide whether the coal measures extend underneath the traps, &c., to the east. If so they would be close to the water carriage of the Ganges. A boring which was made a few years ago with the object of finding out whether any coal occurred with some Barakar sandstones near Akbarnagar, north-west of Rajmahal, did not prove successful. It was carried to a depth of 256 feet without getting through the supposed Barakar sandstone.

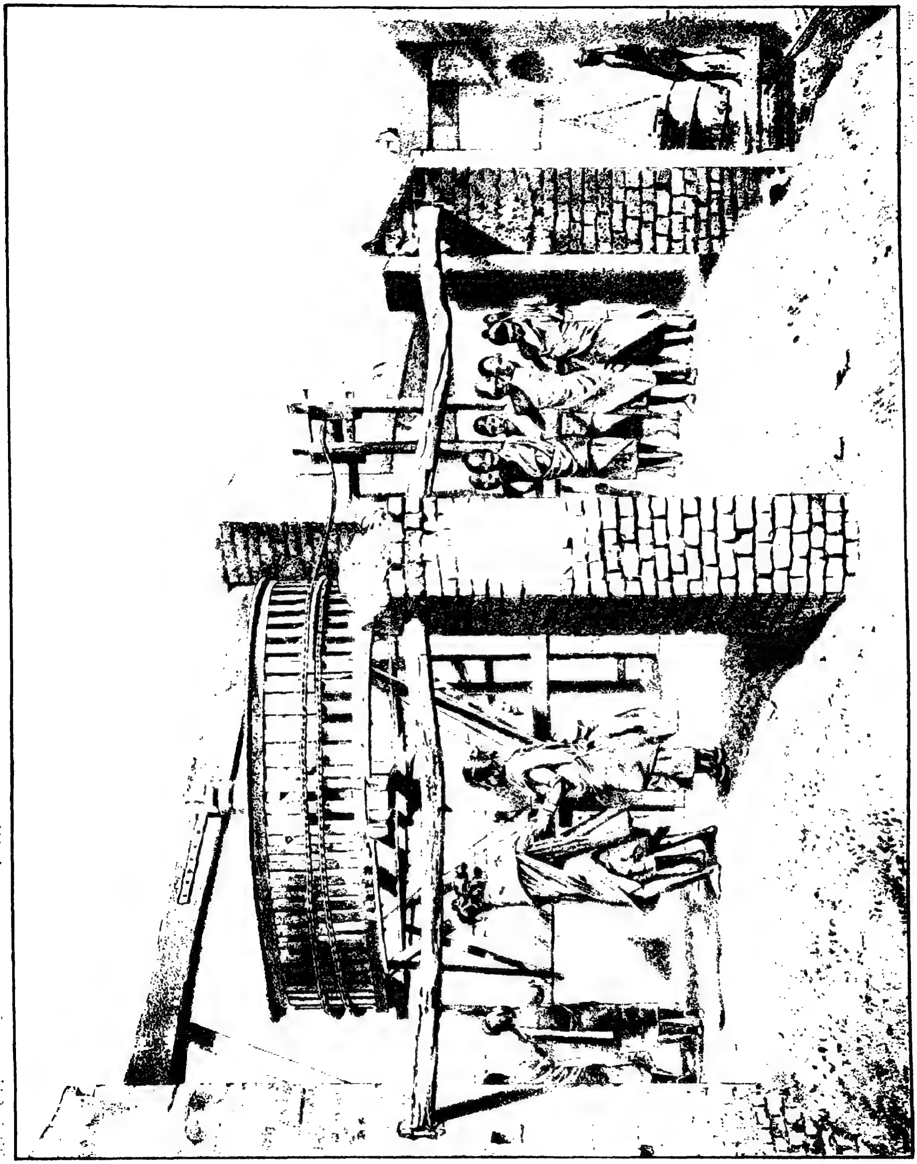
The coal of this area is for the most part stony and bad. It is not now regularly mined, but a large quantity was extracted during the construction of the East Indian Railway. Should the occasion arise for re-opening the mines it is possible that some of the seams might be found to improve to the deep, although past experience of them is not encouraging.

In Dr. Oldham's report on the coal resources of India returns are given of the out-put from these fields for the three years inclusive from 1858 to 1860. The most important mines were in the Hura field, where from two, Hura and Borah, a total of about 40,000 tons was extracted in the two years 1859-60. The next in importance were at Tesaphuli, in the Chaparbhita field, where about 16,500 tons were raised in the three years. Altogether it is probable that not more than 100,000 tons have been raised from these fields, and of that amount a large proportion was very poor stuff.

Jainti, Sahaoori, and Kundit Kuraiah.—Three small detached basins or outliers of coal measures bearing the above names occur in the districts of Birbhum and Deogurh, where metamorphic rocks mainly prevail. These fields are of little or no economic importance, as the coal is of poor quality and limited in extent. Samples of coal from Sahajori, which in Mr. Hughes'[1] opinion represented the fair average quality, yielded, according to Dr. Waldie, 28 to 37 per cent of ash.

Karharbari or Kurhurbali.—This small field, having an area of only 11 square miles, is situated in the district of Hazaribagh, at a dis-

[1] Mem., G. S. I., Vol. VII, p. 247.



tance of about 200 miles from Calcutta by rail. It is of great importance, both on account of its position and the quality of its coal. The sedimentary groups of Gondwana rocks represented in the area are Barakar and Karharbari (coal measures), 500 feet, and Talchir, 600 feet.

According to Mr. Hughes[1] the coal occurs in three principal seams which have an average total thickness of 16 feet. They spread over an area of 8½ square miles. The amount of coal he therefore estimated at 1,360,000,000 tons, and the available portion of this at 80,000,000 tons.

An early sample assay gave the following results—carbon, 66·3; volatile matter, 23; ash, 10·7. In working power the Karharbari coals were stated to be to those of the Raniganj field as 113 : 100.

The most recent contribution to the literature of this field is a valuable paper by Dr. Walter Saise, F.G.S., Assistant Manager of the East Indian Railway collieries.[2] By a somewhat different series of data derived from information subsequently obtained during the course of the mining operations, Dr. Saise arrives at what are practically the same figures, as to the amount of available coal, as those given by Mr. Hughes, namely, 81,366,315 tons. That with variable seams, both as to quality and thickness, such as those which occur in this field, there should be differences of this kind, is only what was to be expected. Thus the Bhadua seam before it was opened up presented a most unpromising appearance, and it was impossible to predict with any degree of safety that it would be found to contain a valuable amount of useful coal. The following tables by Dr. Saise give first the commercial; secondly, the ultimate analyses of the seams; and thirdly, a comparison with Raniganj and English coals.

Table I.

	Specific Gravity.	Ash.	Fixed Carbon.	Volatile matter.	Sulphur.	Calorific power.	Remarks.
Lower Seam	1·37	11·67	67·51	20·82	0·72	12·93	Ash white.
	1·34	9·53	64·67	25·80	0·84	13·20	Caking coal; ash fawn-coloured.
	1·35	9·15	66·84	24·00	0·42	13·20	
Upper Seam	1·33	11·96	60·46	27·59	0·52	12·50	Caking coal; ash white.
Bhadua Seam	1·40	13·60	61·03	25·37	0·80	12·40	Caking coal; ash grey.
	1·40	18·08	61·45	20·46	...	12·26	Ash grey.
Average	1·38	12·33	63·06	24·01	0·66	12·75	
Khundiha Seam	...	22·32	59·10	18·58	...	11·00	Ash earthy.

[1] *L. c.*, p. 243.

[2] Procg. North of England Institute of Mining and Mechanical Engineers, Vol. XXX, 1880.

Table II.

	Carbon.	Hydrogen.	Nitrogen and Oxygen.	Sulphur.	Ash	Remarks.
	71·41	4·28	8·92	0·72	11·67	Upper portion of seam.
Lower Seam	78·00	4·72	6·91	0·84	9·53	Serampore } Lower portion of seam.
	78·20	4·34	7·89	0·42	9·15	Jogitand } Lower portion of seam.
Upper Seam	70·93	4·10	12·49	0·52	11·96	Karharbari.
Bhadua Seam	71·46	4·31	9·83	0·80	13·60	Bhadua.
Bhadua Seam	68·94	3·26	9·72		18·08	Serampore.
	64·38	3·71	9·59		22·32	Ditto.

Table III.

	Specific Gravity.	Ash.	Fixed Carbon.	Sulphur.	Volatile matter.	Authority.
Karharbari . Lower Seam .	1·35	9·15	66·84	0·42	24·00	Dr. Saise.
Karharbari . Average . .	1·38	12·33	63·66	0·66	24·01	Dr. Saise.
Raniganj . Good specimen .	...	10·70	51·80	...	37·50	Memoirs of the Geological Survey of India, Vol. III.
Raniganj . Average of 16 .	...	16·27	51·08	...	32·65	Memoirs of the Geological Survey of India, Vol. III.
Welsh Coal	1·313	3·68	82·66	1·59	13·66	Official Report on coal for navy.
Bristol—Lower series (Steam)	1·312	6·16	69·35	1·56	24·48	Dr. Saise.
„ Upper „ (Gas) .	1·26	5·00	60·67	1·36	33·73	Dr. Saise.

In the first table the calorific powers, which depend principally upon the amount of fixed carbon, were ascertained by Thomson's calorimeter. The figures indicate the number of pounds of water which can be converted from the temperature of 212°F. into steam by one pound of coal. The quality of Raniganj coal varies so greatly that it would probably not be quite safe to rely too implicitly on the results set forth in the third table. Certain seams in the Raniganj field consist of coal quite equal to the best obtainable at Karharbari. Still the fact exists that for steam work the Karharbari coals on the average are superior to those from Raniganj.

The Companies possessing coal mines in this field are the East Indian Railway, the Bengal Coal Company, and Raniganj Coal Association. The first mentioned possesses by far the most considerable proportion of the

area. Accurate statistics of the total amount of coal raised in this field since mining was regularly commenced about 12 years ago are not accessible. Dr. Saise estimated up to the end of 1879 that 1,500,000 tons had been removed. According to the Bengal Administration Reports the total outturn from the Karharbari mines was for various years as follows :—

1867-68	30,000	
1871-72	37,820	
1872-73	70,000	
1877-78	308,386	Out of this the East Indian Railway raised 208,790 tons, of which about 180,000 tons was used on the Railway at a cost, exclusive of carriage, of 5 shillings and 5 pence per ton.
1878-79	381,173	
1879-80	362,844	

Should the output rise to 500,000 tons per annum, as it seems likely to do, the life of the coal-field will be 162 years.

Raniganj[1] **or Raneegunge.**—This field is situated on the rocky frontier of Western Bengal at a distance of 120 miles from Calcutta.

The groups represented with their respective thicknesses are as follows: Upper Panchet or Mahadeva, 500 feet; Panchet, 1,500 feet; Raniganj, 5,000 feet; ironstone shale, 1,400 feet; Barakar, 2,000 feet; Talchir, 800 feet; total, 11,200 feet. In round numbers the available coal, exclusive of waste, was estimated by Dr. Oldham at 14,000 millions of tons.

The Raniganj coal-field is the largest and most important of the areas in which coal is worked in India. Its proximity to the main line of railway and also to the port of Calcutta tend to give it pre-eminence over other less favourably situated localities. The total area of the field which is exposed is about 500 square miles; but it is possible that the real area may be even double that, since on the east the rocks dip under and are completely concealed by alluvium. Throughout this area a central zone includes the principal mines, and the numerous chimneys which occur in this tract make it the 'black country' of India. In the year 1774 coal was known to occur there, and so long ago as 1777 was actually worked. In 1830 several collieries of considerable extent had been opened out and were, we have reason to believe, in a flourishing condition.

In 1872, forty-four mines were at work, nineteen of which turned out upwards of 10,000 tons each *per annum*. At the present time there are five principal European companies engaged in the extraction of

[1] Blanford, W. T. Mem., G. S. I., Vol. III, Pt. I.

coal, while many minor firms and native associations contribute to swell the total amount raised. The five companies with their respective capitals are as follows: Bengal, 2,200,000; Barakar, 150,000; Equitable, 800,000; New Birbhum, 720,000; Raniganj, 825,000 rupees.

Formerly a large proportion of the coal was obtained by open workings and quarries, but at the present day most of the seams which were accessible in this way have been exhausted, and regular mining is now carried on with more or less system. The miners are, however, individually, in some cases, allowed a degree of freedom, or rather licence, which would never be permitted in European mines. They chiefly belong to two races, the Bhauris and the Sontals, the former using the pick, while the latter cannot be induced to work with any other tool than a crowbar, with which they produce an altogether disproportionate amount of small coal and dust. The pillar and stall is generally practised in preference to the long wall system of "getting" the coal. None of the mines are of great depth, and a perfect freedom from fire and choke damp render it possible to carry on the work without its being necessary to adopt the precautions which in England only too often fail to secure the object aimed at. Many of the seams are of considerable thickness; one which is worked contains nearly forty feet of coal. As a rule, however, the very thick seams, especially those in the lower measures, do not contain the best coal. Compared with ordinary English coal, the Raniganj coals and Indian coals generally are very much inferior in working power, still, as is well known in India though not perhaps fully realised in Europe, they are capable of generating steam in both locomotive and other engines. In 1867-68 the total amount of coal raised in the Raniganj and Karharbari mines was 564,933 tons; but in 1871-72 the total amount was only 322,443 tons. In 1878-79 the coal raised in the Raniganj field alone amounted to 523,097 tons, while that in the Karharbari field amounted, as already stated, to 381,173 tons, making together a total of 904,270 tons.

The following is quoted from the resolution on the subject by the Lieutenant-Governor of Bengal for the year 1878-79:—

"The year was a prosperous one for the coal companies of Raniganj. There was a large demand, and production was greatly stimulated. The output is estimated to have been 523,097 tons against 467,924 tons, the average of the three previous years. The number of persons employed was 388,931 men, 194,647 women, and 27,277 children."

The coal from particular seams is of better quality than might be supposed from the average, but the amount of fixed carbon appears to be distinctly less than it is in the Karharbari coals.

The average of thirty-one assays[1] of samples from different mines gave the following results :—

Moisture	4·8
Volatile	25·83
Carbon (fixed)	53·2
Ash	16·17
	100·0

The cost of steam coal at the pit's mouth is from Rs. 2½ to Rs. 3. In Calcutta the same coal costs Rs. 8 to Rs. 9, and in Lahore about Rs. 50; but its price of course varies with the market while the cost of production remains tolerably constant.

JHARIA OR JERIAH.—The Jharia coal-field is situated in the valley of the Damuda River, sixteen miles west of the Raniganj field. It is nearly all included in the district of Manbhum; its area is about 200 square miles. It has been fully described by Mr. T. W. H. Hughes.[2]

The following groups only occur, the higher groups of the Raniganj field being unrepresented; Raniganj, 2,200 feet; ironstone shales, 700 feet; Barakar, 3,000 feet; and Talchir, 900 feet; total, 6,800 feet.

The thickness and quality of the seams varies a good deal, but there is no doubt whatever that this field contains a vast quantity of valuable fuel. One seam has a maximum thickness of 60 feet. The estimated available coal in this area is 465 millions of tons.

Whether this field will be worked in the immediate future depends very much upon the possible alignment of a new line of railway communication with the Central Provinces. The exhaustion or partial exhaustion of coal in the Raniganj area, an event still far distant, may hereafter lead to special arrangements for working it. Twenty miles of very simple tramway would, at any time, bring the centre of it into communication with the present terminus of the branch line to Barakar.

It is somewhat singular to relate that at so early a period as 1777[3] a proposition was made to Government by Messrs. Farquhar and Motte to be allowed to cast shot and shell in this field. In 1839, the abundance of the coal there was announced by Lieutenant Harryngton.[4]

BOKARO.—This field is situated in the valley of the Damuda commencing at a point two miles west of the termination of the Jharia field.

[1] Records, G. S. I., Vol. X, p. 196.
[2] Hughes. Mem, G. S. I., Vol. V, with a map. Manual, p. 185.
[3] Jour., As. Soc., Bengal, Vol. XI, p. 822.
[4] Indian Review, Vol. III, p. 119.

Its area is about 220 square miles. The groups represented are precisely identical with those of the Raniganj field, namely, Mahadava, Panchet, Raniganj, Ironstone shale, 1,500 feet; Barakar, Talchir.

Some of the coal seams are of large size, one of eighty-eight feet having been measured. The quality is generally inferior; still there is no doubt that the field contains a vast store of valuable fuel, the estimated available coal being 1,500,000,000 tons. Except by outcrop workings nothing has been done to develop the resources of this field; small quantities of coal, chiefly for domestic purposes, are occasionally taken from it to Hazaribagh. Owing to its position it is not likely, unless by the establishment of some local industry, that it will ever become available for useful purposes. Even should a line of railway pass through or close to it, as has been proposed, its coal could not, at least for many years, compete favourably with that obtained from other fields which are closer to the great marts. The cost of additional transport would exceed any possible profit. A full account and map of this field by Mr. T. W. H. Hughes[1] was published several years ago.

Ramgarh.[2]—This field is situated to the south of the Bokaro field, in the valley of the Damuda. Its area is 40 square miles.

The following groups only occur, as is the case in the Jharia field; it is uncertain whether the higher groups were removed by denudation or were never deposited: Raniganj, 300 feet; Ironstone shale, 1,200 feet; Barakar, 3,000 feet; Talchir, 850 feet; total, 5,350 feet.

The coal is for the most part of poor quality and limited in extent. There are, however, a good many seams. As to the amount available five millions of tons would probably be a safe figure to put it at. All such calculations, however, are liable to modifications which follow from data which cannot be acquired except by borings or shafts, as the natural outcrops, even supposing them to be visible, are often deceptive. On the one hand an apparently thick seam may die out altogether within a short distance, while on the other weathered coal at the surface or marginal coal at the edge of the original basin of deposit, may not afford a fair index of the quality beneath.

The western extremity of the field is close to the road between Hazaribagh and Ranchi; and it is believed that some of the outcrop coal is occasionally worked by the natives and carried to Ranchi for sale.

Karanpura, North and South.—These fields are situated at the head of the Damuda valley; their areas respectively are 472 and 72 square miles.

[1] Mem., G. S. I., Vol VI., p. 39.
[2] Mem., G. S. I., Vol. VI., p. 109. Manual, Part I, p. 190.

The groups occurring are the same as in the Bokaro field, save that in the southern field no trace of the Panchets has been yet discovered. They are as follows: Mahadeva, Panchet, Raniganj, Ironstone shale, 600 feet; Barakar, 1,500 feet; and Talchir, 400 feet.

The estimated amounts of coal are, for the larger field (North Karanpura), 8,750,000,000 tons, the estimated total thickness of seams being 38 feet. In the South Karanpura field the estimated amount is 75,000,000 tons, the thickness being 70 feet.

The following is an assay of a sample of the better class of coals from these fields which indicates a fuel with high calorific power:—

Carbon	64·5
Volatile	27·0
Ash	8·5
	100·

The situation of these fields in a deep valley surrounded by hills renders it improbable that this vast amount of coal will become available for economic purposes for very many years.

Mr. Hughes has described and mapped both in detail.[1]

North-west and west of Damuda Valley.—Chope.—This is a small field of less than one square mile in extent. The chief point of interest about it is that it is situated on the Hazaribagh plateau, at an elevation of about 2,000 feet above the sea, or nearly 1,000 above the nearest fields in the valley of the Damuda. The groups represented are the Barakar and Talchir. There is only one seam of coal, and it, so far as it is exposed, is of poor quality.[2]

Itkuri.—This field is situated about 25 miles north-west of Hazaribagh. The Barakar coal measures, which include a few seams of inferior coal, are exposed over only half a square mile. The remainder of the area is made up by rocks of the Talchir group.

Aurunga.—This field is situated in the district of Lohardaga, to the west of the sources of the Damuda, in the valley of the Koel, a tributary of the Sone. The area is 97 square miles, and the groups represented are: Mahadeva, 1,000 feet; Panchet, 700 feet; Raniganj, 1,000 feet; Barakar, 1,500 feet; Talchir, 300 feet; total, 4,500 feet.

There are numerous coal seams, some being of large size; the estimated amount of coal which they contain is 20,000,000 tons.

[1] Mem., G. S. I., Vol. VI. Manual, Part I, pp. 191, 196.

[2] Mem., G. S. I., Vol. VIII., p. 347. Manual, pt. I., p. 196.

[3] Hughes, T. W. H. Mem., G. S. I., Vol. VIII, p. 331. Manual, part I, p. 97.

The following average proportions of constituents derived from the assays of seven samples from different localities indicate a very poor quality of fuel:—

Moisture	6·7
Volatile	29·3
Carbon	36·5
Ash	27·5
	100·

As valuable and extensive deposits of iron ores, together with limestone suitable for flux, occur in and near the coal-field, this inferiority of the coal is to be lamented, as should a project for manufacturing iron there ever be adopted, fuel, it seems probable, will have to be obtained from one of the neighbouring fields, thus increasing the cost of production. Before 1877-78, when it was examined and mapped,[1] only the vaguest information existed as to the extent and character of this field. No coal has ever been extracted from it. The samples above referred to were all taken from exposed and weathered-out crops, and it is therefore to be remembered that the possibility of a better quality of coal being obtained, should the field ever be opened up, exists in this case as it does in some of those previously mentioned.

Hutar.—This field lies to the west of the Aurunga, being situated more directly in the valley of the Koel. The area is 78·6 miles and the following groups occur: Mahadeva, 1,000 feet; Raniganj and Barakar, 2,750 feet; Talchir, 300 feet; total, 4,050 feet.

Data for the estimation of the quantity of available coal are wanting, but there are a considerable number of seams, and the average of eight assays gives the following favourable result:—

Moisture	5·95
Carbon	55·35
Volatile	28·
Ash	10·7
	100·

It is somewhat strange that the coal of this field attracted notice earlier than that at many more accessible localities. And a 'cole mine' is marked on a map by Rennell, which is dated 1779. During the season 1877-78 it was examined and mapped.[2]

[1] Mem., G. S. I., Vol. XV, Part I, p. 55.
[2] Mem., G. S. I., Vol. VX, Part I, p. 91.

DALTONGANJ.—This field is also in the valley of the Koel and in the district of Lohardaga. The area is 200 square miles. Two groups only are represented, *viz.*, the Barakars and Talchirs, the latter being about 500 feet thick.[1]

Seams of coal are not numerous; one, which has a thickness of about five or six feet, contains excellent fuel, according to the Indian standard, as the following average of four assays amply testifies:—

Moisture	3·45	per cent.
Carbon	64·8	"
Volatile	21·05	"
Ash	10·7	"
	100·	

The estimated total of available coal is 11,600,000 tons.

This field has been worked to a small extent from time to time. There is now a prospect of its being opened up again in connection with the Sone river canal system. To test the actual amount of coal and the distribution of the seams, a well-conducted series of borings, more especially in the eastern part of the field where the rocks are much hidden, is urgently required. The construction of a steam tramway, which is to connect the field with the canals, has already been commenced.

Mr. Taylor first worked the coal mines at Rajhara for four or five years up to 1848, but the undertaking was then abandoned.[2] Regular mining operations, which were subsequently undertaken by the Bengal Coal Company, were brought to a sudden close by the mutiny. Since then the mining has been on a small scale.

Sone Valley, &c.—TATAPANI, IREA, AND MORNE.—It is difficult to assign an area to these fields as they are really only portions of an enormous tract stretching far to the westwards which is occupied by Gondwana rocks. If, however, the tract which includes them and the younger rocks be taken as being bounded on the west by the Rer river, all beyond remaining for separate treatment, then the area may be set down at 650 square miles.

The groups which occur in the Aurunga and Karanpura fields are all represented here. The Barakar group alone contains coal which is noteworthy since in the Aurunga field the Raniganj group contains coal to a small extent showing its gradual extinction from east to west.

Mr. Griesbach, who has recently described this area,[3] indicates the existence of several coal seams of workable thickness and many too small for that purpose. No estimate has yet been made as to the

[1] Hughes, T. W. H. Mem., G. S. I., Vol. VIII.

[2] Selections from Records, Bengal Government, No. XX, Part 3, p. 1.

[3] Mem., G. S. I., Vol. XVII.

general quality and quantity of the coal. Owing to the manner in which the coal measures (Barakars) are covered up and isolated by the younger groups, it is not likely that there is a large quantity of available coal; and in consequence of the difficult and hilly nature of their surroundings it seems unlikely that there is an immediate prospect of their possessing any commercial value.

Singrowli and Sohagpur.—This is a wide tract in the Sone valley, covering upwards of 2,000 square miles. It is believed that nearly all the recognised groups of the Gondwana formation are represented within the area. As in the previous case, the actual coal measures are separated into distinct fields by the overlying younger groups. These may temporarily be distinguished under the above titles. During the past two working seasons Mr. Hughes has been engaged in the examination of these fields, and the following remarks are in anticipation of the full details which may be expected from him when he has gone over the whole area. In the Southern or Sohagpur area both the Barakar and Raniganj groups occur, but coal seams are of rare occurrence and of no great promise, so far as their appearance at the outcrop admits of an opinion being formed.

In the Northern or Singrowli area there appear to be a greater number of outcrops of coal and the Kota colliery in that area was worked for some years and has yielded coal of fair quality. The amount raised was limited, however, owing to the distance (eighty miles) over very bad roads, which the coal had to be carried to Mirzapur where alone there was any considerable demand for it.

Jhilmilli.—This is a small area of about 35 square miles, which has not yet been fully examined. Besides Talchir and Barakar rocks one or more of the younger groups are represented.

Coal seams of some promise have been observed in the Barakar measures. Traces of coaly matter, forming a seam of six inches, were also discovered in the Talchirs—a quite exceptional circumstance. This field serves to link the Gondwana sedimentary rocks of Central Sirguja with those of Rewa, &.[1]

Bisrampur.—This field occupies the central basin of Sarguja at an elevation of about 1,800 feet above the sea. Its area is about 400 square miles. The formations met with are—Mahadeva, 1,000 feet; Barakar, 500 feet; and Talchir, 200 feet.

A large number of coal seams has been discovered, some containing good coal, but so far as is at present known they are not of great promise.[2] Still there is a fair prospect of coal suitable for locomotives being found, should locomotives ever be taken there to burn it.

[1] Manuscript Notes and Manual, Part I, p. 204.

[2] Records, G. S. I., Vol. VI, p. 81, with a map.

Central Sirguja is so landlocked that at one time it seemed of all things the most unlikely that this field would ever become the scene of mining operations. The '*role*' of prophet could be much more efficiently performed in this and some other instances if all future alignments for branch lines of railway were known beforehand. Supposing, however, that a railway should pass through the field its coal is not likely ever to compete with that of the fields outside.

LAKHANPUR.—This field lies to the south of the Bisrampur area, from which it is separated by a fault and a belt of Talchirs, with inliers of metamorphic and sub-metamorphic rocks. Its total extent has not yet been ascertained, but it is probable that it is continuous with a large area of coal-measure rocks, known to exist to the westwards in the Hasdu valley.

Several seams of coal have been discovered, one of which is five and a half feet thick and contains good coal. The rocks belong to the Barakar and Talchir groups.[1]

RAMPUR.—This area adjoins the last on the north, and it is probable is more or less connected with that which follows, but it is partly situated in a different catchment area near the sources of the Rer river, a tributary of the Sone, while the field about to be described is wholly within the limits of the Mahanadi basin. The rocks of this portion belong to the Mahadeva, Barakar, and Talchir groups. No good coal has been observed yet. The most remarkable seam is situate at the base of the massive square block of Mahadeva rocks known as the Ramgarh Hill. Above it issues a perennial fountain of water, which, with some other peculiarities, has caused the spot to be regarded as one of great sanctity by the natives.[2]

Mahanadi Valley.—RAIGARH AND HINGIR.—UDAIPUR AND KORBA.—The above-named places are situated in a wide extent of coal measure and associated rocks, which occupy an area of not less than 1,000 square miles. Much of the country is very wild and difficult of access, and our knowledge of the field is as yet imperfect. Especially this is the case as to the identity of the rocks younger than the Barakar coal measures. There appear to be two distinct groups, one containing fossil plants, which serve to correlate it with the Kamthi-Raniganj group, the other being probably of Mahadeva age, but, owing to the great similarity in lithological characters, separation has been attended with great difficulty and uncertainty.

[1] Manuscript Notes and Manual, Part I, p. 206.

[2] Manuscript Notes and Manual, Part I, p. 207. Jungle Life in India, p. 324.

The coal seams are sometimes of enormous size, thicknesses as great as 90 feet at Korba, and even 168 feet in Hingir, having been measured; but although including good coal, these are often largely made up of carbonaceous shale, which is incapable of supporting combustion. Sometimes, too, the seams die out within surprisingly short distances, so that it becomes impossible to predict the limits of their horizontal extension.

In one locality, the Samasota river, a tributary of the Mand, the coal seams have been greatly disturbed, being bent into a steep anticlinal, at the crest of which the lower rocks of the area, Talchirs and Metamorphics, are exposed.

Whatever alignment be adopted for the line connecting Calcutta with the Central Provinces, this field will doubtless be opened up, and may, in that contingency, become of great importance.

Satpura Basin.[1]—The Satpura basin, so called from a range of hills included within it, is situated south of the Narbada valley. It is difficult to speak of this area as a single expanse of coal measures, since, as a matter of fact, they only appear at intervals under the margins of younger groups, covering a wide extent of country which stretches for a distance of about 170 miles. Accordingly, the estimated dimensions of the basin vary much according to different authorities. About 2,000 square miles appears to be a safe minimum, but besides this it should be remembered that there is a considerable tract in which the underlying formations are concealed by the tertiary Deccan traps, and a large area towards Jabalpur, in which no coal measures have been proved to exist under the younger formations which prevail there.

In this region the several groups of the Gondwana system are developed to their maximum extent, as has been fully described in Part I.

The principal localities where coal measures occur are near Mopani and in the valleys of the Tawa (Shahpur or Betul field) and Pench (Chindwara field) rivers. Under the orders of the Chief Commissioner of the Central Provinces, advised by the Geological Survey, borings[2] have been made both in the alluvium of the Narbada valley on the margin of the rocky area and in valleys to the south of it within the area occupied by the younger rocks, but though these borings were carried to considerable depths, the coal measures were not reached: these depths were, Gadawara, 251 feet; and Sukakheri, 491 feet. Neither of these when stopped had proved the rocks underlying the recent alluvial deposits. In

[1] J. G. Medlicott. Mem., G. S. I., Vol. II, pp. 97, 267; H. B. Medlicott. Idem, X, pp. 133, 188; Records, G. S. I., Vol. III, pp. 63, 70, and VIII, pp. 65, 86.

[2] *Vide* Annual Report of the Geological Survey for 1877. Records, Vol. XI, p. 7.

the Dudhi valley borings, at Manegaon to the depth of 420 feet and at Khapa to the depth of nearly 720 feet, established the fact that the younger formations still persisted, the coal measures, if they exist below not having been reached. As the progress of boring by hand at 720 feet was slow and costly the work was abandoned.

Borings at Tandui, ten miles west of the Mopani field, which it was hoped might prove a similar area of coal measures on the margin of the basin, were unsuccessful. Two of them at depths of 328 and 172 feet respectively struck contact and trappean rocks, and another further south, at 243 feet, had to be abandoned owing to the tools sticking, and as the dip of the beds was high there was no inducement to renew the attempt.

Near Lokartalai on the Moran, at the western extremity of the basin, where some carbonaceous outcrops occur, borings were put down to depths of 254, 84, and 88 feet, but without proving coal. In the open valley of the Tawa on the south of the basin at Kesla, on the Betul and Hosungabad road, borings to the depth of 302 and 241 feet had the same result as the boring at Khapa.

Other borings between the Piparia and Bunkheri stations, on the Great Indian Peninsular Railway respectively and Pachmari, although sunk in deposits belonging to the upper Gondwanas, close to Talchir outcrops, failed to reach the coal measures which are there consequently overlapped.

Mopani.[1]—This field is one of high importance in consequence of its position with reference to the railway. It is situated 95 miles (by rail) west-south-west of Jabalpur, and 322 miles from Allahabad, or 83 miles nearer than the Karharbari field to the same place.

The area in which coal has been proved to exist is small, though recently an important addition appears to have been made. The original area is much cut up by faults, and the largest seam has been destroyed by fire. The seams are—

1. Inferior coal	12 feet not worked.	
2. Good cooking coal	18-20 feet on fire.	
3. Good „	3 feet 4 inches	worked together.
4. Ten feet good „	12 feet	

These seams are and have been worked for many years by the Narbada Coal and Iron Company. In 1874 the outturn ranged from 700 to 1,000 tons per month. In 1875 nearly 20,000 tons appear to have been raised, but in 1879, according to the Administration Report of the

[1] Medlicott, J. G. Mems., G. S. I., Vol. II, 1859, p. 2; Medlicott, H. B. Idem, Vol. X, 1873; Records, G. S. I., Vol. III, 1870; Vol. IV, 1871, p. 66; Vol. V, 1872, p. 109; Vol. VIII, 1875; Vol. XII, 1879, p. 95.

Central Provinces, the total had fallen to 12,410 tons. The coal is sold to the Railway Company at about Rs. 10, or at from three to four times the price of Raniganj and Karharbari coals. It can command this price in consequence of the cost of carriage respectively of Karharbari and of English coal from Bombay. The present outturn falls far short of the requirements of the Railway.

In 1878 the average cost of Karharbari coal on the line between Jabalpur and Allahabad, as has been already stated, amounted to £1 2*s*. 4¾*d*. per ton.

Shahpur or Betul Field.[1]—The coal outcrops on the south of the Tawa valley are of no great promise; they are of irregular thickness and the coal is generally inferior. Since the failure to prove coal near the northern outcrop of the basin, or in the open Tawa valley, borings are now being made to test the seams of the Shahpur field.

Pench.—There are many seams in this area, some of which are of considerable thickness, and the coal is often of fair quality. The position of the field, surrounded by hilly country, renders it improbable that it will ever be of much commercial value.

Wardha-Godavari Valleys.—Bandar.[2]—This field is situated near the village of Chimur, 30 miles north-east of Warora, in the Chanda district. The existence of coal measures under a small tract of Kamthi beds, five to six miles square, has been proved by boring. Three seams of coal have been ascertained to exist, and these have a maximum total thickness of 38 feet. The coal is similar in character to that of Warora.

Wardha or Chanda, &c.[3]—This coal-field constitutes the northernmost extremity of an immense tract of Gondwana rocks, which extends for about 285 miles from north-west to south-east in the valleys of the Wardha, Pranhita, and Godavari basins.

The groups of rocks exposed are as follows: Kota Maleri, 1,500 feet; Kamthi, 2,500 to 3,000 feet; Barakar, 250 feet; Talchir, 500 feet; the Barakar alone containing coal.

Any attempt to give an idea of the distribution of coal measures throughout this area, without employing a mass of detail unsuited to the present volume, would certainly fail. It will sufficiently answer our purposes to quote Mr. Hughes's estimate of the amounts of coal, in several

[1] J. G. Medlicott. Mem., G. S. I., Vol. II; W. T. Blanford. Records, G. S. I. Vol. 1, p. 5; H. B. Medlicott, op cit, Vol. VIII, pp. 69-75.

[2] Hughes. Mem., G. S. I., Vol. XIII., pp. 145-154; Manual, Vol. I, p. 226.

[3] Hughes. *L.c.*, pp. 1-145.

of the particular tracts, where its existence has been proved by actual outcrops or by borings:—

	Actual Quantity. Tons.	Amount Available. Tons.
Warora basins	20,000,000	14,000,000
Ghugus	90,000,000	45,000,000
Wun	2,100,000,000	1,500,000,000
Between Wun and Papur	105,000,000	50,000,000
Between Junara and Chicholi	150,000,000	75,000,000
Sasti and Paoni basins	60,000,000	30,000,000
	2,525,000,000	1,714,000,000

The following assays will serve to convey some idea of the quality of the coals:—

		Warora.	Pisgaon.	Ghugus.
Fixed Carbon		45·4	65·1	45·61
Volatile	Combustible	26·5	19·2	33·49
	Water	13·9		
Ash		14·2	15·7	20·90

In Mr. Hughes's "Memoir" assays of samples from other localities are also given.

The Warora coal is deficient in fixed carbon, a large percentage of which is essential where great heating power is required. It is also deficient in combustible volatile gases. Pisgaon coal, however, contains a more considerable proportion of fixed carbon, *viz.*, 65·1 per cent.

The only pits in this wide area which are worked are at Warora, where the outturn in 1878 amounted for a time to 1,500 tons per week. The great outlay by the Government in connection with the exploration and testing of the field[2] has not yet been nearly repaid, the cost of getting the coal being heavy. A recent falling off in the outturn, the amount of which will be seen from the table given on a previous page, was caused by a serious flooding of the mines in 1879, which put a stop to all work for a time. A special branch line conveys the Wardha coal to the Nagpur branch of the Great Indian Peninsular Railway, by means of which it is distributed both for use on this line and in factories.

List of extra-peninsular areas where coal measures occur.

	Age.
Cutch.	
1. Trambal	Jurassic and Tertiary.
Sind.	
2. Lainyan	Tertiary.

[1] Average of sixteen assays.

[2] £60,000 is stated to have been already expended at Warora alone at the time Mr. Hughes's report was printed.

Afghanistan.	
3. Bolan Pass	Tertiary.
4. Chamarlang	"
5. Kanigaram	"
Punjab.	
6. Trans-Indus Salt Range . . .	Jurassic and Tertiary.
7. Cis-Indus Salt Range . . .	Tertiary.
North-West Himalayas.	
8. Numerous localities from the Jhelum to Nepal	"
Sikkim.	
9. Foot of Darjiling Hills . . .	Damuda or Permio-triassic.
Dafla Hills.	
10. Dikrang river	Damuda or Permio-triassic.
Assam.	
11. Makum	
12. Jaipur	Tertiary.
13. Nazira	Tertiary.
14. Jangi	Tertiary.
15. Disai	Tertiary.
16. Eastern Naga Hills	Tertiary.
Garro Hills.	
17. Harigaon	Cretaceous.
18. Siju	Cretaceous.
19. Daranggiri	Cretaceous.
20. Rongenggiri	Cretaceous.
21. Um-blay	Cretaceous.
Khasi Hill.	
22. Mao-beh-lyrkar	Cretaceous.
23. Cherra Punji, &c., &c. . . .	Tertiary (nummulitic).
Jaintia Hills.	
24. La-Ka-dong, &c.	Tertiary (nummulitic).
(*Sylhet*)	Tertiary.
(*Cachar*)	Tertiary.
(*Chittagong*)	" (and Cretaceous?)
BURMA (BRITISH).	
Arakan Division.	
25. Baronga Islands	Tertiary.
26. Ramri Island	"
27. Cheduba Island	"
(Sandoway)	"

Pegu Division.

28. Thayetmyo	Tertiary.
Tenasserim Division.	
29. Thoo-hte-khyoung	Tertiary.
30. Hienlap or Hienlat	„
31. Kan-ma-pyeng	„
32. Tsing Koon	„
33. A-tong-wa	„
BURMA (NATIVE).	
34. Thingadaw, &c.	Tertiary (and Cretaceous?)
Andaman Islands.	
35 Port Blair, &c.	Tertiary (and Cretaceous?)
Nicobar Islands.	
36. Kondul, Treis and Track Islands .	Tertiary (and Cretaceous?)

Cutch.—As early as the year 1834, if not before it, hopes were entertained that coal seams of good quality and workable thickness would be found in the jurassic rocks of Cutch. Captain Grant, R.E., was appointed to conduct boring and mining operations. In his first report[1] he appeared to be sanguine that a useful discovery would result; but in a subsequent paper[2] he states that the coal had not been found in workable thickness, and much that was raised from the thin seams proved to be slaty and incombustible. These seams were situated at Trambal (Tromba or Trombow), about five miles to the north-east of Buj, in a river bed north of Sisagad and in a stream west of Guneri near Lakhpat. At the first-mentioned locality Mr. Blanford[3] was able to measure the seam in the old workings and found that it was one foot four inches thick, of which only half was coal. At Sisagad the coal proved very frangible, and it was, on trial, found to fall through the gratings of the furnaces.

Mr. Wynne,[4] who examined the area in detail, was of opinion that no better quality nor larger amount was to be found in the whole of Cutch. Besides the above, which are all of jurassic age, Mr. Wynne also found there carbonaceous layers in some of the tertiary beds, but none of these were of any promise.

Sind.—In the oldest (lower eocene) tertiary rocks of Sind, which have been named the Ranikot group by Mr. Blanford, traces of coaly matter or rather lignite have from time to time attracted notice; but in only one instance has anything more than a mere layer of a few inches

[1] Jour., As. Soc., Bengal, Vol. III, p. 40.
[2] Trans., Geol. Soc., London, Vol. V, Second series, p. 292.
[3] Mem., G. S. I., Vol. VI, p. 23.
[4] *Op. cit.*, Vol. IX, p. 86, and Bombay Gazetteer, Vol. V, p. 19.

thick been detected. This was at Lainyan (Lynan or Leilan), 27 miles north-north-west of Kotri and 15 miles from the right or western bank of the Indus. In the year 1857 Mr. Inman, who was in charge of the exploration, sunk a shaft, but found that the coal, which was at first five feet nine inches thick, rapidly dwindled down to nothing, galleries which were driven to north, east, and west failing to prove a continued thickness, while at the outcrop there was only a thin layer of carbonaceous shale. Mr. Blanford, who visited and reported on the locality,[1] states that there was no true coal seam, but merely a mass of lignite not extending much more than 50 yards in any direction. This lignite proved to be brittle and abounding in iron pyrites, which caused by its decomposition a tendency to spontaneous combustion.

In the Public Works report[2] it is stated that the sulphurous fumes which were given off were not only most offensive but they also proved injurious to bars of furnaces and tubes of locomotives. For smithy purposes it was of course inapplicable.

Balochistan and Afghanistan.—Bolan Pass, Lat. 29° 50′ 30″; Long. 67° 15′ 30″.—Travellers through the Bolan Pass have often had their attention attracted by the coaly matter which is exposed in the rocks of eocene age, near Much, and which are traversed by the line of route. Owing to its small quantity, as testified to by Captain Hutton[3] and Dr. Cook[4] it was evidently worthless. This view has been fully confirmed by Mr. Griesbach's examination of the locality.[5]

Some trial of this coal was recently made, it is believed, at Quetta, but the result is not known.

Chamarlang.—Lat. 30° 15′; Long. 69° 35′ 30″.—Proceeding northwards the next locality to which particular attention has been directed is situated in the Chamarlang valley, in the Luni Pathan country, about 75 miles to the west of Dera Ghazi Khan. The discovery of coal here by Sir Robert Sandeman, which proved on analysis to be of good quality, led to the writer[6] being deputed to visit and report upon it in the year 1874. The principal seam proved to have a maximum thickness of only nine inches, with a dip of 30° to the south-east. Numerous smaller seams, of from two to three inches thick, were met with, and information was obtained regarding others of similar character on the outer slope

[1] Mem., G. S. I., Vol. VI, p. 13, and Vol. XVII, p. 192.
[2] Procdgs., Public Works Department, 1861-62, p. 34.
[3] Calcutta Jour., Nat. Hist., Vol. VI, pp. 570 and 601.
[4] *Vide* Hughes's Balochistan, p. 22.
[5] Mem., G. S. I., Vol. XVIII, p. 27.
[6] Records, G. S. I., Vol. VII, p. 145.

of the Suleman range, which doubtless belong to the same horizon, a zone in the lower tertiary or eocene rocks, the probable affinities of which have already been discussed in this manual, Part II., p. 505.

All the evidence that could be obtained bore out the conclusion that there were no solid grounds for hoping that a seam of workable thickness would be found. It is believed that recently (1879-80), while this region was in occupation by our troops, search was made for a more promising deposit, but without success. Had one of a workable thickness been found equal in quality to that above mentioned, its value might be estimated by the following assays, which indicate a bituminous coal with fairly high heating powers. Like all or most of these tertiary coals on the western side of India it is very friable. The following assays are by Mr. Hughes :—

	A.	B.
Loss by drying (= water)	6·7 per cent.	8 per
Carbon	57·8	59·2
Volatile	38·8	35·8
Ash	3·4	5·2
	100·	100·2

It does not coke. As it is jet-like in appearance, with no sign of vegetable structure, it would perhaps be incorrect to speak of it as a lignite.

Kanigaram.—Lat. 32° 30′ 30″; Long. 69.° 40′. Near Kanigaram, in the Waziri country, coal has long been known to exist. From its position and the description of its characters, it is probably of the same age as that at Chamarlang. Specimens from this and several other localities were received from Sir Alexander Burnes, and two of the former gave the following results on assay by Mr. Prinsep[1] :—

	A.	B.
Loss by drying	3·5 per cent.	5·4 per cent.
Carbon	48·5	45·3
Volatile	49·1	48·6
Ash	2·4	6·1
	100·	100·
Sp. G.	1·227	1·481

It is therefore more bituminous, and would have less heating power than the Chamarlang coal. The seam is said to be narrow and is laid

[1] Jour., As. Soc. Bengal, Vol. VII, p. 854.

bare by a water-course on the side of a hill for a distance of 112 yards. Its exact position is stated to be about three miles east of the small village of Luagarkhel, under the Malik Buda.

Captain Drummond evidently refers to this locality in his enumeration of places in Afghanistan where coal has been found; the other localities are Dobandi in the Ghilzai country; Hissaruk (?Hissarlik), and Syghan, in the Hazara country. The Dobandi seam is said to be thin and the Syghan coal ignites with difficulty. Captain Hutton mentions a report that coal occurs in abundance in the hills of the Hazara country. Several of the specimens of supposed coal, which were forwarded to Mr. Prinsep by Sir Alexander Burnes for examination, proved indeed to be more or less combustible, but were not coal. They were products of petroleum, or clay or rock saturated with them.

Punjab.—The coal of the Punjab has for many years attracted notice, the great importance which a supply of good fuel would possess, if found in the vicinity of the Indus, having caused attention to be directed to every spot where any trace of carbonaceous matter had been seen on the surface. In the year 1833 Lieutenant (afterwards Sir Alexander) Burnes wrote a short account[1] of what was supposed to be coal from the neighbourhood of Kohat, where it was found near the petroleum wells. From the description and analysis of this substance which are given it is evident that it was merely earth or shale saturated with bitumen. In his letter of instruction regarding his trip to the Oxus, Lieutenant Wood was directed by Sir Alexander Burnes[2] to direct his attention to the possibility of obtaining a supply of coal. In 1838 Mr. Prinsep[3] published analyses of samples of jetty coal, lignite, and bitumen forwarded by Sir Alexander Burnes. He pointed out the apparent resemblance in the mode of occurrence between these deposits and those containing the coal and petroleum of Assam. It would be useless to follow and attempt to correlate the observations of all who have written on this subject since the year 1843. A list of references to their papers will be found in the Appendix.

Taking the accounts by Dr. Oldham,[4] Mr. Wynne[5] and Mr. Lynam[6] as containing the most recent authentic accounts by experts who have carefully examined the ground, we find that the following are the most

[1] Jour., As. Soc., Bengal, Vol. II, p. 267.
[2] Personal Narrative, Introduction, p. 8.
[3] Jour., As. Soc., Bengal, Vol. VII, p. 848.
[4] Memorandum on the examination of the Salt-range, &c.
[5] Mem., G. S. I., Vols. XI, XIV, XVII.
[6] Trans., American Phil. Socy., 1873, p. 13.

important facts in reference to the carbonaceous deposits of the Punjab. But first it may be well to offer a possible explanation of the difference in the extent of the carbonaceous deposits in the tertiary rocks of North-western from that of those of North-eastern India.

It is possible that in tertiary times the meteorological conditions which determined the amount of moisture in the air may have been of a character directly comparable to those of the present day, though, as the relative positions of land and sea were different, they cannot have been identical. In Assam there is now an abundant rainfall and luxuriant vegetation, and these conditions must have existed when the materials of the large coal seams were formed. In the Punjab there is but little rainfall and a sparse vegetation. Such a type of vegetation as, if it or anything like it existed in tertiary times, before its quantity could have been diminished by human influence, would have been sufficient to supply materials for the formation of the limited nests of lignite and thin seams of coal which are all that have as yet been proved to exist in the Punjab rocks. Some of these indeed may owe their origin to mere accumulations of sea-weed. Nothing, however, which is said here is intended to imply that continously workable seams of coal cannot occur in the Punjab or in any of the adjoining countries to the west and south, but the evidence all points to the conclusion that such seams have no existence. In many places there are complete sections of the upturned edges of the rocks unobscured by vegetation where, if coal occurred, it must be visible.

The rocks containing carbonaceous matter may conveniently be separated geographically into those which occur to the west and the east of the Indus respectively; as will be seen, they are not all of the same age. The following is an abstract from Dr. Oldham's memorandum.

Mullakheyl, Lat. 32° 55′ 30″; Long. 71° 13′.—Up the stream which issues from the hills, at Mullakheyl and thence southwards, probably at many places intervening between it and the localities mentioned in Afghanistan, where the carbonaceous sub-nummulitic limestone zone is exposed, coal occurs in the alum shales, but it is only in irregular strings and nests. At Mullakheyl itself, too, masses of carbonized wood are found in the older jurassic rocks.

Chushmen, Lat. 32° 55′ 30; Long 71° 19′ 30″.—In a deep gorge, one of the drainage channels round Chushmen, and high upon the scarp there are thin strings and nests of coal in the alum shales; the quality is not bad, but there is no sign of a large seam.

Kotki, Lat. 32° 59′; Long 71° 28′.—Here there is a recurrence of beds of both nummulitic and jurrassic age containing coaly matter, the

former being found at the south end of the Chichali Pass; the latter on a side gorge very difficult of access.

Kalabagh, Lat. 32° 58′; Long. 71° 38.—The nummulitic coal here is in very small quantity in the alum shales. The so-called Kalabagh coal, which attracted notice at one time, consists of carbonized masses of wood in a bed of shale, of which they only form one-twentieth or one-twenty-fifth part or less. This shale has been shown to be of jurassic age. It was estimated by Dr. Oldham that about 45,000 maunds of this coal could be obtained, but there was nothing to justify expenditure for machinery.

The above localities are all in the continuation of the Salt-range to the west of the Indus. Those which follow are in the Salt-range proper, and the order of their arrangement is from west to east. They are all in nummulitic rocks.

Amb or Umb, Lat. 32° 30′; Long. 72°.—otherwise known as Sulge. The coal here is described by both Dr. Oldham and Mr. Wynne[1] as being of no value, being of limited extent.

Sunglewa.—Two thin seams, one of six inches and the other of 10 to 12 inches; the dip is 30°. They are much broken; no prospect of being profitably worked.

Chamil, Lat. 32° 35′ 30″; Long. 72° 28′ 30″.—Seams similar to the above, dip only 12°, and locality not difficult of access, but no workable quantity of coal.

Kutta, Lat. 32° 37′ 45″; Long. 72° 25′ 45″.—Thin broken bed; no prospect of a continuous supply. Almost all the coal that could be obtained here has been taken away.

Sowa Khan, Deiwal, Nurpur (Nilawan), and Karuli.—The coal at these localities is very limited in extent.

Nila, Lat. 32° 39′ 30″; Long. 72° 57′.—Coal poor in quality; dip 30° to 35° to south-east; coal more than 15 inches thick; there are eight feet of blackish shales below it with thin layers of flaky coal.

Dandot, Lat. 32° 39′ 30″; Long. 73°.—There are three localities in this neighbourhood where coal is seen; where thickest it is two feet six inches thick. The fuel is not bad, but there is no prospect of its occurring in profitable quantity.

Pid, Lat. 32° 41; Long. 73° 2′.—Here there is a seam of good bright fuel, three feet thick in places; the dip is 60° to 64°. As the locality is near a good road a fair amount of fuel might be obtained as the coal contains less pyrites than elsewhere, but it breaks up on exposure; mining to the deep would of course be difficult.

[1] Mem., G. S. I., Vol. XIV, p. 235.

From this locality and another called Samundri, between the years 1863 and 1867, nearly 2,000 tons were extracted according to Dr. Oldham's mineral statistics,[1] but the excavations were afterwards abandoned.

Reora or Khewra, Lat. 30° 40′; Long. 73° 4′.—This locality is above the gorge; the coal is poor and full of iron pyrites; it is much mixed with layers of shale. The total thickness is 2 feet 11 inches. A small heading was driven into it, but there is no prospect of the coal being worked with advantage.

Bhaganwalla, Lat. 32° 42′ 30″; Long. 73° 19′.—The outcrop of this seam, which is three feet six inches thick, extends for a distance of two miles; the dip is 63° to north. The coal is greatly cracked and jointed; when exposed to the atmosphere it disintegrates and falls to pieces. Crystals and flakes of gypsum commonly occur in the cracks and fissures in the coal. There is also much iron pyrites which on decomposition gives rise to spontaneous ignition. Much care is therefore needed, if this seam (or any of those in the Salt-range) be worked, to keep the galleries clear of dust and small coal. Good masses of bright coal might be obtained by successive galleries one over the other. The locality is difficult of access, but is improvable in this respect. Dr. Oldham's estimate of the coal available here was 16,20,000 maunds.

This completes the list given by Dr. Oldham and endorsed by Mr. Wynne. As to quality it was found by experiments that in locomotive engines and steamers the work which one maund of this coal was capable of doing was equal to that from 2·5 to 4 maunds of wood.

So long as the seams mentioned above, especially those at Bhaganwalla and Kalabagh, could be made to yield coal at a cheap rate by simple excavations, for so long would they prove of value. Dr. Oldham estimated that while the coal could be sold for three maunds a rupee at Kalabagh, it would be cheaper than wood at five maunds, which was the price in 1864; but he felt certain that after all the easily accessible coal had been removed, the greater expense of working would render it impossible for it to be brought to market at that rate.

Chita Pahar Range.—All the foregoing localities in the Salt-range are situated on the southern outcrops of the sedimentary series. On the north-west side of the Potwar, or Rawul Pindi plateau, which is formed of the younger tertiary rocks, the older formations are again upturned in the Chita Pahar range, which is the connecting link between the moun-

[1] Mem., G. S. I., Vol. VII, p. 150.

tains of Southern Hazara and the Afridi hills south of the Peshawar Valley. Throughout these ranges the nummulitic series is repeated several times by contortion and faulting, and the carbonaceous beds in it can be traced at many places; locally they include nests of light coal as at Choi, south of Attock.[1]

North-west Himalayas.—It will be convenient to treat collectively under the above heading the carbonaceous deposits which occur near the southern foot of the Himalayas from the Jhelum to Nepal. First must be mentioned, and for the last time on this side of India, the coal of nummulitic age. The tertiary rocks cross continuously from the Hazara district into the Jamu hills with an abrupt and total change of strike along the Jhelum. The lowest member of the series only comes to the surface at a few places in this ground where some massive inliers of very old limestone protrude through the sub-Himalayan rocks. Upon and around these the nummulitic group is freely exposed, and at its base there is a greater development of coal, so far as is known, than in any other part of North-western India. Dandli, near Kotli on the Punch and the north-western shoulder of the Saugar Marg mountain may be mentioned as favourable localities.[2] The position, however, seems to preclude the possibility of profitable exploitation.

When the base of the series is next exposed to the east, in the Simla region, where it was first described as the Sabathu group, all trace of carbonaceous deposit has vanished, although its horizon is perfectly recognisable.

We now pass to the carbonaceous deposits of younger tertiary age in the sub-Himalayan rocks. Sir Proby Cautley[3] appears to have been the first to draw attention to these deposits, which he did in the year 1828. At Silani, under Nahan, seams of coaly matter of from half an inch to three inches thick were discovered, and at the Kalawala Pass leading into Dhera Dhun accumulations of vegetable matter turned into lignite were found in two localities. Captain Herbert[4] apparently refers to the same locality as the Timli Pass, and he states that the substance had the appearance of common charcoal with the woody structure well preserved. At the Kheri Pass carbonaceous matter occurred both in seams and as imbedded logs or stumps. Another locality is in the bed of the Bulia near Bhamauri and near Ranibagh close to Hulduani.

That from Bhamauri occurred in a seam of four inches thick; it

[1] Wynne, A. B. Records, G. S. I., Vol. X, p. 114.
[2] Medlicott, H. B. Records, G. S. I., Vol. IX, p. 13.
[3] As. Res., Vol. XVI, p. 387.
[4] As. Res., Vol. XVI, p. 397.

showed no woody structure having the appearance of jet, but was very brittle. The composition of Ranibagh coal was—[1]

Carbon	60·0
Volatile	36·4
Ash	3·6

In 1833[2] Mr. E. J. Ravenshaw forwarded samples of lignite and jetty coal from the Dhela river in the north of the Moradabad district. These occurred only in thin nests and layers and contained a good deal of iron pyrites.

Mr. Medlicott,[3] in his review of the whole question of these carbonaceous deposits, while anxious not to deter any explorer from investigating so important a subject, points out that the result of experience is unfavourable to the prospect of coal being found in useful quantity.

Mention must here be made of another rock in this region, but amongst the older formations of the higher hills, regarding which as a source of coal expectations have occasionally been raised. Visitors to Simla and Mussooree cannot fail to notice considerable local outcrops of black crumbling rock: it is a carbonaceous shale that occurs normally below the main (Krol) limestone of those hills. Where the rocks are much crushed, along lines of faulting or of flexure, the carbonaceous ingredient of their shales becomes condensed with a jet black shiny substance, of coaly appearance. An attempt at coal mining was once undertaken in this fault-rock near Sabathu. Mr. Medlicott states that in none of the sections which he examined, from the Ravi to the foot of the hills at Naini Tal, had he met with a single grain of true coal in these older rocks.

Sikkim: Darjiling District.[4]—This field occupies a narrow zone, which stretches along the foot of the Himalayas from Pankabari to Dalingkote. It was first noted by Sir J. D. Hooker in 1849. The rocks belong to the Damuda formation. They have been much crushed and tilted, dipping at angles of from 40° to 90° to northwards or towards the main mass of the hills. Frequently the sandstones have been altered into quartzites, and the shales into splintery slates. Much of the coal is in the condition of powder, and some of it has assumed the character of graphite. The effect of the compression has been to reduce it by removal of the volatile portions to a condition approximating anthracite. Some experiments were made with a view to utilising

[1] Economic Mineralogy of Hill Districts, by E. T. Atkinson, p. 32.
[2] Jour., As. Soc., Bengal, Vol. II, p. 264.
[3] Mem., G. S. I., Vol. III, p. 180.
[4] Mallet, F. R. Mem., G. S. I., Vol. XI.

it in the manufacture of artificial fuel, but the process found to be requisite was too expensive, and the difficulty of mining in these crushed rocks is so great as to render it improbable that this coal will ever be commercially available.

One seam is 11 feet in thickness. The average of five assays of the coal gives the following composition :—

Carbon	70·66
Volatile	9·20
Ash	20·14
	100

The fact that this locality and that next to be mentioned are the only ones, north of the Ganges, where Gondwana rocks occur, is of great interest in connection with any discussion as to the early relations which existed between the Peninsular and Himalayan regions, and indeed the formation of the Himalayas themselves.

Tertiary lignites of no value have been examined in the sub-Himalayan rocks of the Tista Valley by Dr. Oldham. Other similar deposits occur in the Bhutan hills, where they have been examined by Colonel Godwin-Austen and others.

Dufla Hills.—Damuda rocks were discovered in 1875 by Colonel Godwin-Austen[1] in the section in the Dikrang river.

A much splintered and crushed seam, which was five to six feet thick and dipped 75° to east-south-east, was found. In character it was similar to those above described; it is scarcely probable that it will ever possess any economic value.

Assam.—Five distinct and named coal-fields exist in the valley of the Bhramaputra, in the province of Assam. They are distinguished by the following names: Makum, Jaipur, Nazira, Janji, Disai. Besides these, in the further extension of the Naga hills up the valley to the frontiers of Burma, there are other known but not regularly explored localities where coal occurs. It will be convenient in this abbreviated account to treat of them collectively.

Some uncertainty exists as to the age of the rocks, but the balance of evidence seems to favour the view—*vide* part II, page 702—that it is middle tertiary (miocene), and therefore distinct from that of the cretaceous and nummulitic coals of the Garo and Khasi hills.

[1] Jour., As. Soc., Bengal, Vol. XLIV, p. 37.

The coal differs from that of the Peninsular coal-fields in having a homogeneous unlaminated structure. The average composition, as derived from the assay of twenty-seven samples, gave :—

Carbon	60·
Volatile	36·2
Ash	3·8
	100·

This is a high quality of fuel as compared with ordinary Indian coals. In the Makum field one seam, which is 100 feet thick, consists of 75 feet of good coal, and some seams have been traced for long distances by their outcrops.

Already, in Part II., a general sketch of these fields has been given, and to Mr. Mallet's report[1] reference must be made for fuller details.

The opening up of these fields is a point of the highest importance, since, at present, coal is carried 1,000 miles from Bengal for the navigation of the Bhramaputra; this causing a tenfold increase on the prime cost, while at the same time the coal of the Peninsular fields, as will be seen by a comparison of assays, is of very inferior quality.

The extension of the railway system up the valley will soon, it is to be expected, solve the difficult question of carriage which has hitherto interfered with the development of the coal and petroleum resources of Assam.

Garo Hills.—The existence of coal in several localities in the Garo hills has now been known for about forty years. The great importance which a supply of coal would possess, if in close proximity to the Bhramaputra, caused attention to be directed to all localities where the occurrence of carbonaceous matter gave ground for the least hope that a workable source of coal would be found.

In the year 1842 Mr. James Bedford explored the so-called Karaibari field. This name is, however, hardly a suitable one, as it is that of the zemindari or district in which the localities are situated, but these are far removed from the thanna of Karaibari, and therefore the name Harigaon, suggested by Mr. Medlicott,[2] as indicating the exact neighbourhood, has been since adopted. There is a continuous outcrop of the cretaceous rocks which include this coal from the Bhramaputra eastwards along the southern edge of the Tura range. This constitutes the main basin in which these rocks dip southwards under a thick series of tertiary deposits. At Siju, in the Sameswari valley, coal which is possibly continuous throughout is again exposed; this may conveniently be described as the second field.

[1] Mem., G. S. I., Vol. XII, p. 2. Manual, Vol. II, p. 701.
[2] Records, G. S. I., Vol. I, p. 11.

To the north, resting on and surrounded by gneiss, there are a number of detached basins in which the coal is better seen; of these, the principal are the Daranggiri field, situated in the valley of the Sameswari or Semsang; the fourth bears the name Rongenggiri, and the fifth Umblay. So far as is at present known, all the coal of the Garo hills is of cretaceous age. This list does not exhaust all the possible localities where coal measures may occur.

Harigaon Field.—Harigaon, Lat. 25° 36′; Long. 90°, on the Kalu river, has given a name to this field, but the original localities where coal had been observed were at Salkura, Champagiri, and Mirampura.

At Sulkura and Mirampura the so-called coal Mr. Medlicott found to be a resinous shale, while at Champagiri, further north but between the other localities, the bed is a dark stiff clay with insignificant strings of lignite. The presence of this somewhat amber-like resin has been referred to by several previous writers[1]; being disseminated in globules through the shale, it causes it to burn freely. The Coal Committee[2] pronounced these to be deposits of spurious brown coal, but they were under the impression that a valuable bituminous coal of distinct character existed in the valley of the Bunarossi, a tributary of the Kalu, where a bed was found by Mr. Medlicott which consisted of a few sticks of lignite scattered through sandstone at from six to ten feet above the gneiss. Fragments of jetty lignite met with higher up the stream were obviously from a similar source. The rocks containing these carbonaceous deposits are all of cretaceous age, and Mr. Medlicott points out that they are on the same line of strike as the coal of Siju, in the valley of the Sameswari, the including zone having originally been, if it be not still, continuous throughout. Should the seams thicken and improve in quality to the dip, away from these marginal outcrops, a point which can only be tested by borings, the coal will only be accessible by pits in which a large water discharge must be anticipated. Mr. Medlicott suggests Dipkai as a favourable spot.

Although Mr. Medlicott found the nummulitic rocks well represented in this area, there was no sign of the presence in them of the coal which is found overlying the nummulitic limestone of the Khasia hills.

Siju, Lat. 25° 20′; Long. 90° 43′.—The coal at this locality as seen at the outcrop, though somewhat better than that of the Harigaon area, is neither of sufficient quantity or quality to make it probable that it will pay for the difficult transport to the nearest navigable part of the

[1] Griffiths' Private Journals, p. 78, note. Dr. Oldham's Report on Coal Resources of India, p. 18.

[2] Final Report, 1846, p. 121.

Sameswari. An attempt was formerly made by the Raja of Sushung to work the coal.

DARANGGIRI FIELD.—This field is in a true rock basin, 300 to 400 feet above Siju. Several fine outcrops of coal were found by Mr. Medlicott[1] in addition to one brought to notice by the officers of the Topographical Survey.

A promising outcrop of a nearly horizontal seam, fully seven feet thick, is seen at the foot of a cliff near Daranggiri. In other spots the seams were disturbed. The total area of the field amounts to from, at the least, 12 to 15 square miles. It lies in the very heart of the Garo hills, but on the most favourable line for a railway, through the gorge of the Semsang, should it be decided to undertake such a work.

An analysis of this coal gave the following results:—

Carbon	47·7
Volatile	44·6
(Moisture 11·5).	
Ash	7·7
	100·

RONGENGGIRI FIELD.—Further up the valley there is another basin, which extends above and below the outpost of Rongenggiri, where these coal-bearing cretaceous rocks occur. No actual outcrops have as yet been seen, but Mr. Medlicott suggests that coal may exist below the present surface.

The possibility of the existence of a more accessible source of coal below the Tura range is discussed by Mr. Medlicott, who proposes that a boring should be made to the deep near Dipkai, two miles north-east of Putimari Haut.

UMBLAY FIELD.—Further to the east Colonel Godwin-Austen[2] discovered a basin of cretaceous coal-measures of similar character. He states that, unlike the nummulitic coal of the Khasi hills, it is persistent over a large area and is often to be found in a series of separate seams. The exact position of the portion of the basin which is most likely to be utilised is between the meridians 91° 10′ and 91° 20′ of East Longitude and south of the parallel of 25° 26′ of North Latitude.

In the scarp at Nougheran four coal seams were seen, measuring respectively 3 feet 4 inches, 3 feet, 8 feet, and 6 feet, or a total of 20 feet 4 inches.

Khasi Hills.—The coal of the Khasi hills has attracted notice for more than fifty years; indeed, so early as the year 1815, Mr.

[1] Records, G. S. I., Vol. VII, p. 59.

[2] Jour., As. Soc., Bengal, Vol. XXXVIII, part 2, p. 1.

Stark sent down a sample which was favourably reported on at the Cossipur gun-factory. A very full account of the early history of this coal will be found in the report on the Khasi hills by Dr. Oldham.[1] As will be seen by the references, there is a somewhat extensive literature on the subject.

In these hills coal occurs in both the cretaceous and nummulitic formations. The great difficulty experienced in the transport of this coal to market is due to the high elevations at which the different basins are situated. The following is a list[2] of the localities with their elevations where coal is known to exist: (1) By-rang, altitude 1,242 feet above sea-level; (2) Cherra Punji, 4,118 feet; (3) Lait-ryng-iew 4,800 feet; (4) Mao-long, 600 feet; (5) Mao-stoh, 1,500 feet; (6) Mao-syn-ram, 4,000 feet; (7) Mao-don, 400 feet; (8) Mao-nai-chora, 300 feet; (9) Mao-beh-lyrkar, 5,000 feet; (10) Shella, 800 feet; (11) Thanjinath, 4,400 feet. Much remains to be done in the way of exploration before a full account of the coal resources of these hills can be written. In the above list the most important areas are Mao-beh-lyrkar (Maubelarkar in Part II) and Cherra Punji.

MAO-BEH-LYRKAR.—The age of the coal at this locality was ascertained to be cretaceous by Mr. H. B. Medlicott.[3] Not only did the somewhat obscure geological relations point to that conclusion, but the mineral characters of the coal itself were found to be identical with those of the Garo hills coal above described; the texture is compact and splintery with conchoidal feature, and specks and nests of fossil resin are included. The abundance of pyrites is a drawback to its usefulness as a fuel (*vide* Part II, p. 689).

The deposit is of inconsiderable extent, but it has been worked to supply the station of Shillong, which is 18 miles distant, where the cost is Rs. 30 per ton. The seam is only from 3 feet 6 inches to 4 feet thick.

Mr. Mallet[4] has described the occurrence of coal at a place called Dedum, near Maolong, which he thinks could be more easily taken to Shillong. The analyses he gives show, however, a very inferior quality of coal:—

	Dedum.	May-beh-lyrkar.
Carbon	37·8	55·2
Volatile	24·6	39·6
Moisture	6·0	3·4
Ash	31·6	1·8
	100·	100·

[1] Mem., G. S. I., Vol. I, p. 185.

[2] Statistical Account of Assam, Vol. II, p. 232.

[3] Mem., G. S. I. Vol. VII, p. 175.

[4] Records, G. S. I., Vol. VIII, p. 86.

CHERRA PUNJI.—The coal of Cherra Punji is of nummulitic age. It occurs about 10 or 12 feet above the limestone in a bright-looking seam of somewhat variable thickness owing to interpolations of sandstone. This nummulitic coal has more the appearance of the ordinary bituminous mineral, and is more stony than that from the cretaceous basins.

Dr. Oldham's[1] estimate of the amount of coal available here was that therewas an average of 3 feet 6 inches to 4 feet of coal over an area of one-third of a square mile, and that this would yield from 387,000 to 447,000 tons.

Various attempts have been made to work mines here, but the cost of carriage has prevented the industry from being a source of much profit to those who have leased the mining rights.[2]

Jaintia Hills.—In the Jaintia hills carbonaceous deposits are reported to exist at five localities, namely, (1) Am-wi, 3,800 feet; (2) La-ka-dong, 2,200 feet; (3) Narpur, 500 feet; (4) Sha-tyng-gah, 3,500 feet; (5) Sher mang, 4,000 feet.

LA-KA-DONG.—Dr. Oldham (*l.c.*) states that the coal of La-ka-dong, which is also of nummulitic age, is so irregularly developed that it is very difficult to give a regular estimate. However, he puts the area at half a square mile, with an average thickness of three feet; this would give 1,500,000 tons of coal.

La-ka-dong is within six miles of Borghat, a village on an affluent of the Surma, which is accessible all the year round by boats of 500 maunds or 18 tons burden; but at present cooly carriage only is available between La-ka-dong and Borghat.

A special report with maps of this field by Dr. Oldham[3] was published in the year 1853. In it are given estimates for working the coal and transporting it to market, according to which the cost in Calcutta, in 1853, would be Rs. 43 per 100 maunds, independently of cost of superintendence, interest on capital, &c., which he considered would add 25 per cent. to this amount, so that the cost per maund would be about $8\frac{2}{3}$ annas.

Sylhet and Cachar.—So far as the evidence at present goes, there is no workable seam of coal in either Sylhet or Cachar. It being quite unknown to what extent the nummulitic, eocene, or older tertiary rocks are developed there, no opinion can be given as to the probability of a valuable supply of coal, of the character of the Upper Assam coal, being found.

[1] Mem., G. S. I., Vol. I, p. 192.

[2] Statistical Account of Assam, Vol. II, p. 233.

[3] Selections from Records, Bengal Government, No. XIII, p. 45.

Hitherto the samples of supposed coal which have been forwarded to Calcutta from these districts for examination have invariably proved to be merely lignite or jetty coal from nests, and it is probable that the rocks in which these were found belong to the younger tertiary groups. As petroleum is stated to have been found on the banks of the Barak and Sarang rivers, the nummulitic rocks are probably not far off, and local observers need not feel discouraged, but should redouble their efforts to discover actual outcrops.

As there is a prospect of some of the Assam coal-fields being, ere long, worked by companies, the following may prove useful:—

Rules for the lease of sites for Coal-workings in Upper Assam,—that is, in the Districts of Sibsagar and Lakhimpur.

1. Sites granted for coal-working may not exceed fifty acres of coal-bearing rocks, nor may more than one site be leased to one person or in one interest.

2. Leases of such sites may not be granted for a period longer than fifty years.

3. Leases of such sites may not be granted before they have been surveyed and their boundaries demarcated.

4. The rate of revenue to be charged for such sites shall be Rs. 3 per acre per annum.

5. A royalty of eight annas per ton shall be charged for all coal carried beyond the limits of the grant.

6. The lessee shall commence quarrying or mining operations within two years of the date of his lease.

7. The lease shall be liable to cancelment on breach of any of the above conditions.

8. If during the currency of the lease royalty be paid annually on less than 100 tons of coal mined on the site for five years successively, the lease shall be cancelled.

9. Nothing in these rules shall be considered to limit the right of the Legislature to impose any regulations for the working of coal mines in Assam which it may consider desirable.

The above were in force in 1878, but they may have been modified since.

Chittagong.—From time to time samples of brown coal or lignite from the Chittagong Hill Tracts have been received at the Geological Survey office for examination and report. In no case have they been of a character to encourage a hope that coal occurs in sufficient abundance to be profitably worked.[1] The great value which coal would possess,

[1] Oldham, Dr. T. Coal Resources of India, 1867, p. 18. Bengal Administration Report, 1870-71, p. 239.

if found at an easily accessible distance from Chittagong, has proved an incentive to research by the local officials. All the specimens received are believed to be of tertiary age and probably come from the nummulitic rocks, which are known to form a portion of the hills, where, however, cretaceous rocks also occur. Samples forwarded for assay in the year 1870 gave the following poor results:—

	A.	B.
Carbon	36·5	25·9
Volatile	38·	35·8
Ash	25·5	38·3
	100·	100·

A included a quantity of pyrites.

British Burma.—Arakan Division.—From the number of references quoted under this head, in the list of authorities given at the end of this volume, it will be seen that for a period of nearly 50 years attention has been directed to the carbonaceous deposits of Arakan. These admit of being discussed in three groups, the northern including the Baronga Islands, the central including Ramri and Cheduba, and the southern the mainland in the Sandoway district.

Baronga Islands.—These are three islands situated south of Akyab harbour. They are parallel to one another and strike in a north-western to south-eastern direction, averaging about 20 miles long. On the western coast of the eastern island called Angara-Khyong, about two or three miles from its southern extremity, coal is said to have been found at three localities below high-water mark. In one place it was thought that the bed of coal was 5 feet thick; in another 18 inches; the third being very small. The dip was said to be south-west by west. On the central island called Peni-Khyong, at the southern end, coal in a seam of 1 foot thick was reported to exist.[1]

Mr. Mallet, in his description[2] of the petroleum of these islands, suggests the possibility that the lignitiferous beds, from which the petroleum has in all probability been derived, occupy submarine areas between the islands. He says: "The similarity of the rocks in the Barongas and the observed dips lend some little support to the idea that the Phadu and Chengdamma channels mark the position of anticlinal beds with a synclinal between in the position of the middle island." This view, supposing that a really workable seam does exist, presents a more hopeful prospect than Dr. M'Clelland's, which represents the coal under the sea in

[1] Coal Committee's final report.

[2] Records, G. S. I., Vol. XI, p. 207.

a synclinal trough, and, therefore, probably unworkable, while on the other supposition it would be accessible at no great depth on the islands; but the dips are so high and the probability of the existence of a large seam of continuous thickness so slender, that in spite of any results from assays no future can be safely predicted for these deposits, though it is conceivable that a limited amount of useful fuel might be obtained.

Samples from Baronga were forwarded to the Geological Survey by Colonel Sladen, and through the Economic Museum, for examination; the former proved on examination to be lignite in which the woody structure was apparent. The assays gave the following results:—

Water	4·5	5·0
Volatile, exclusive of water	37·5	35·8
Carbon (fixed)	49·6	52·3
Ash (orange-red)	8·4	6·9
	100·	100·
Specific Gravity	3·1	

It is not known where the exact spots were whence these were obtained, or whether they occurred in real seams or merely in nests, as is not improbable.

The five-foot seam mentioned above, if it ever really existed, does not appear to have attracted notice of late years, though its position cannot be far from the petroleum wells. A sample of coal forwarded by the Baronga Oil Company to England for examination by Mr. Redwood was subjected to destructive distillation and yielded 13·74 per cent. of tar and 12·03 per cent. of ammonical liquor. The sample would not coke and it contained 8 per cent. of ash. As these carbonaceous deposits exhibit every variety, from a woody or fibrous to a jet-like structure, opinions will differ as to the applicability of the terms lignite or coal. If the substance possesses heating power, or is suitable for the manufacture of gas, supposing it to occur abundantly, the name which is applied is not material.

Ramri Island.—Although attention has been directed to the carbonaceous deposits of Ramri for many years, only one seam, giving even a slight promise of containing coal in workable quantity, has as yet been discovered. Some ten or a dozen localities might be mentioned where at different times hopes were raised that a source of fuel would be found. In the majority of cases these proved to be only lenticular nests of lignite, or, in some instances, single logs of carbonised wood imbedded in the sandstones; in the others, the seams were too thin and too steep, as at Hoong and near Kyouk Phyu, to be worked. Under these circumstances it is pleasant to be able to quote from Mr. Mallet's report[1]

[1] Records, G. S. I., Vol. XI, p. 209.

his account of a seam or rather seams of slightly more promise, but it must be stated that these are unlikely ever to possess any very high commercial value.

TSETAMA.—The best seams occur less than one mile west 10° north of the village of Tsetama. One seam has a thickness of six feet, and the other, two feet five inches. The dip is 50°. The outcrops reminded Mr. Mallet of the appearance of some of the inferior seams of Upper Assam, and the rocks are believed to be of the same geological age,—that is to say, nummulitic or eocene. The coal is apt to fall to pieces after a short exposure.

Besides the high dip there is one other circumstance unfavorable to the prospect of the six-foot seam ever proving largely productive, and this is that in the upturned edges of the beds with which it occurs it does not appear except at this one spot, so that its lateral extension is probably limited. Mr. Mallet, in concluding his remarks on this coal, says that sea-going steamers, with Bengal and English coal at command, would certainly not take such coal as that which has been found at Ramri owing to its deficient heating power and friable nature.

He believes that the cost of raising it would be so high that it would probably not find a market for local purposes at Akyab.

The following assays are by Mr. Mallet :—

Seam.	Carbon.	Volatile.	Hygrosopic water.	Ash.	Caking properties.	Colour of Ash.
Tsetama	43·5	28·8	8·4	19·3	Cakes slightly.	Reddish grey.
„ six-foot seam .	38·4	28·9	14·6	18·1	Does not cake.	Light grey.
„ one-foot seam .	48·6	33·1	10·8	7·5	Cakes . .	Red.

CHEDUBA ISLAND.—Mr. Mallet (*l. c.*) describes a seam which is seen in a stream which descends from a hill north-east of Pallang Rao. It is only two feet six inches thick and dips to east-20°-south at an angle of 40°. It is similar in appearance to the coal at Tsetama. A carbonaceous sandstone was described by Captain Halstead[1] as occurring less than a mile from the beach to the south of Pagoda Hill.

SANDOWAY.—On the mainland of Arakan, in the neighbourhood of Sandoway, thin carbonaceous deposits have from time to time been discovered and samples of lignite from the Arakan Hill Tracts have been forwarded, but at present there are no solid grounds for believing that a deposit of value exists in these regions. It is possible that some of these may be of cretaceous age.

[1] Jour., As. Soc., Bengal, Vol. X, p. 444.

Pegu Division.—Near Thayet Myo (or Thaiet Mio[1]) coal was discovered in the year 1855, and a mine was opened which at first gave good promise of yielding a quality of coal that would have been most serviceable for the steam navigation of the Irawadi. Owing to the beds being nearly vertical, mining would have been attended with considerable difficulty. This might not have proved an insurmountable obstacle; but the fact that the two seams which were originally discovered gradually merged into one, which ultimately died out, led to the abandonment of operations after a few hundredweights had been extracted. Another seam, also worthless, was discovered, according to Mr. Theobald,[2] near the village of Chouk-kalah on the Mu stream, 3 miles south of Tham-bayadeing boundary pillar. It is a bed of carbonaceous shale including one foot of hard coal and a few stringy seams, amounting in all to 18 inches. The dip is 70° to east by north. Its situation is more than 30 miles from the Irawadi.

The latest examination of this coal was made by a gentleman employed by a Rangoon firm in 1878[3] to report on the petroleum. Having had experience of coal-mining, his opinion was that it would be impossible to work the deposits profitably, as the quality, quantity, and the state of the communications were all unfavorable.

At Dalhousie, near the mouth of the Bassein river, and in other places as in the Shu stream above Sabatau, traces of carbonized trunks or lignite have been met with, and have given rise to fallacious hopes of a source of fuel. The rocks in these localities are also of the older tertiary, nummulitic, or eocene age.

Tenasserim Division.—In the Tenasserim Division coal has been found in the tertiary rocks at a number of localities, and, as will be seen by reference to the list of authorities at the end of this volume, there are a good many papers on the subject. Dr. Helfer appears to have been the earliest writer on the subject. In the year 1838 he made his first discoveries and described them in glowing language, which was only exceeded by the terms "inexhaustible beds of uniformly good quality" made use of by the Coal Committee. A *résumé* of the literature will be found in the recently published "British Burma Gazetteer."

In the year 1855 all the then known localities were either visited by Dr. Oldham or conclusive information was obtained regarding them. Out of thirteen named localities, in five,—namely, Bankyop, Tagoo Creek,

[1] Oldham, Dr. Selections from Records, Government of India, Vol. X, p. 99; and Coal Resources of India, p. 18.

[2] Mem., G. S. I., Vol. XI, p. 342.

[3] British Burma Administration Report, 1877-78, p. 35.

Banpyai and Manton, on the Great Tenasserim river, and in Tagit Creek on the Little Tenasserim no coal exists,—black carbonaceous deposits incapable of supporting combustion having been mistaken for coal. Out of the remaining eight localities two were too remote to be visited, and the occurrence of coal was doubtful.[1] The following gives in brief the results of the examination of those possessing a possible value.

THOO-HTE KHYOUNG OR THATAY KHYOUNG, Lat. 12° 30′; Long. 99° —On the Great Tenasserim, about the year 1841, a coal mine was worked here by Government, but was subsequently abandoned, although considerable expenditure had been incurred. The seam, including partings, was 11 feet 8½ inches thick, of which 6 feet 8 inches was true coal. The dip is 20° to 15° north of east. Iron pyrites is very abundant, but the coal was easily wrought, being turned out in good cuboidal masses with little waste, and it was found to answer fairly well in steam-engines. The steep dip of the beds was, in Dr. Oldham's opinion, the most serious objection to working the mines, as the site is not unfavorably situated, being within three-fourths of a mile of the river, but the navigation is difficult for about 80 miles to the port at Mergui.

As remarked by Mr. Fryar,[2] who visited the locality subsequently, the question of working these mines hinges upon the demand likely to arise for the coal. Were it of a quality equal to Indian steam coal, it is doubtful whether it could contend with it successfully at Indian ports; and of local demand there is none, the monthly steamer from Maulmain to Mergui using wood fuel on the return journey.

HIENLAP OR HIENLAT.—This locality is the name of a village about 6 miles north of Thoo-hte-khyoung. The seam is 17 to 18 feet thick, and the coal is of pretty uniform character with conchoidal fracture. It comes out in large masses, but these break down after exposure. It does not coke, but breaks up, leaving little ash. Pyrites is not so abundant as in the coal of the last-mentioned locality. An assay by Dr. Macnamara shows that it would be rather deficient in heating power, still a trial made by H. C. S. *Pluto*, of 100 tons of this coal, brought down to Mergui by a Burman, yielded satisfactory results. The specific gravity is 1·28. The assays of this and of the coals from the following localities, although they have several times been quoted, are not given here, as they seem to have been erroneously copied, or, if not, the proportions of constituents cannot be treated as percentages since the totals considerably exceed 100.

[1] Selections from Records, Government of India, Vol. X, p. 31.
[2] Indian Economist, Vol. IV, p. 43.

As working at the outcrop by the natives was calculated to injure this seam in reference to future operations, Dr. Oldham recommended that if systematic working was contemplated the former should be put a stop to. For the first lot of this coal Rs. 24 a ton was paid at Mergui to the Burmese contractor, who, however, was willing to enter upon a new contract at the rate of Rs. 16 a ton.

Kan-ma-pyeng.—This locality is situated three-fourths of a mile north of Hienlap. The main seam of coal is about 8 feet, but pyrites is abundant, otherwise the coal is similar to the last. In situation it is nearer the river, but the landing place is not so good. The other localities in this valley appear to be unimportant.

Little Tenasserim River—Tsing Koon.—This locality is 121 miles from Mergui and 80 miles from Tenasserim. Dr. Oldham, accompanied by Mr. Chase, spent five days journeying in canoes and 11 miles marching through the forest before he reached this spot from Tenasserim. It was in reference especially to this coal that the above-quoted remarks were made by Dr. Helfer and the Coal Committee. The seam or seams examined by Dr. Oldham were too small to be of any practical value; the quality, were it not for the presence of a certain amount of pyrites, is good. The dip is 18°. This locality is on the frontiers of Siam. Although the tract in which it is situated was once thickly populated, there are now no human habitations.

Lenya River—A-tong-wo, Lat. 11° 25′ ? Long. 99°.—This locality is about 8 miles above the Lenya village on the Lenya river, which joins the sea south of Mergui. It took five days travelling in canoes, numerous shallows being encountered before the spot was reached.

The coal is exposed in the bank of a small tributary called the Phlia; but it unfortunately proved to be only an irregular bed varying from 1 foot to 2 feet 6 inches in thickness; it is throughout laminar with thin seams of jetty coal between the layers, and very numerous imbedded nodular lumps of a resinous amber-like substance. The whole appearance of the rocks suggested that they were more modern than those of the Tenasserim district. The coal and associated rocks dip at from 35° to 38°, to between 15° and 30° north of east. The coal ignites with some difficulty, but retains its shape after the lumps become red hot. The amber-like resin causes it to blaze up. It comes out of the bed in large solid masses, and if it occurred in abundance would be a useful fuel for many purposes.

In Dr. Oldham's concluding remarks he states his belief in the probable identity of the Thoohte (or Thattay) and Heinlap seams, but the Kan-ma-pyeng seam probably belongs to a higher horizon.

The coal could, he considered, be laid down at Mergui if worked on a large scale for Rs. 10 a ton. The latest opinion as to the extent of the demand has already been quoted, but the fact should be borne in mind that this field contains coal in sufficient quantity and of such a quality as to render it possible that it may yet become commercially valuable.

Upper (or Native) Burma.—The only detailed accounts of the appearance and character of coal seams in Upper Burma are by Dr. Oldham,[1] whose observations at Thingadaw were made during the mission of Sir Arthur Phayre to Ava in the year 1855, and by Dr. J. Anderson[2] during the expedition to Western Yunan. Some notes by Major Strover on the mineral resources of Upper Burma[3] more recently published, give additional localities, and these it will be most convenient to mention first. Coal is known to exist at Thingadaw, about 70 miles above Mandalay, on the western bank of the Irawadi; at Shuaygu below Bhamo; at Meinbaloung in the Shan states east of Mandalay; to the south-west of Mandalay in the Yaw district, at Yaignaw, east of Nat-taik. It is found also at Pagan and Shimpagah. Major Strover states the coal at Meinbaloung has been examined by a Mining Engineer, and that it is said to be a true mineral coal quite equal to the best English. Coal is known to exist in the Hukong valley, where amber is found, as has been described on a previous page.

THINGADAW, Lat. 28° 45′; Long. 95°.—This locality is situated on the western bank of the Irawadi, at some distance from the three points where the coal outcrops visited by Dr. Oldham lie. The most southernly of these is in a stream bed 10 miles west of the village of Tembiung.

The seam, which is 4 feet thick, dips to west-30°-south at 15°. It contains a large proportion of impurity in the form of black powdery soot and black clay. It disintegrates rapidly on exposure, and even at first, on account of its flaky and cracked condition, it cannot be got out in large lumps. In the year 1855 it had been worked to some extent, but its sale in Pegu had not proved remunerative.

The second locality is on the upper waters of the Kibiung stream, 5 miles further north and 5 miles west of Thingadaw. The coal here with the included shale is 5 feet 6 inches thick; dip 5° to 8° to west. The structure is flaky and woody, and includes an amber-like resin in nests. This appears to have been formed from the exudation of the sap of the wood, which on decomposition formed the coal.

[1] Colonel Yule's mission to Ava, Appendix E, p. 332.

[2] Report on expedition to Western Yunan, pp. 198, 199.

[3] Indian Economist, Vol. V, p. 14.

The third locality is 8 miles north-west of Thingadaw. The coal is hard, compact and jetty, with small imbedded lumps of amber-like resin. The thickness is 3 feet 9 inches to 4 feet, and the dip 8° to north-east; both floor and roof are good. This is the most promising locality of the three. A good deal of coal had been raised but none removed, as the country was impracticable for carts; but as the distance was only 7 or 8 miles to the Irawadi, Dr. Oldham considered that the deposit was likely to become a valuable one. There is now a depôt for this coal at Thingadaw, where the steamers take in fuel.[1] The seams at the first and second localities were thought to be the same, while this was considered to occupy a higher horizon; no fossils were found to show the age of the beds, but it is possible that they may prove to be cretaceous like those containing similar resinous coal elsewhere.

Dr. Anderson[2] visited two coal mines to the west of the village of Kabyuet, which appear to be further south, though possibly on the same horizon as those above described. One of these, called Lek-ope-bin, is 6 feet thick, and the dip is to the south-west at an angle of 35°. It is distant about 5 miles from the river. The other is at Ket-zu-bin to the north-east of Lek-ope-bin on the banks of a small stream. It is said to contain the best coal; two of the openings had been flooded and the other only recently commenced.

Half a dozen men worked in each pit, their only tools being axes and chisels in wooden handles. The amount mined is therefore inconsiderable, and the coal comes out in very small pieces.

Andaman Islands.—Traces of coal have been met with in several of the islands of the Andaman group, but as yet no regular seam has been discovered. The deposits consist of nests which, in every case where any excavation has been attempted, have been speedily exhausted. The rocks are either of the oldest tertiary or most recent cretaceous age, and probably belong to the same group as those of Negrais of the Arakan Yoma (*vide ante*, Part II, p. 733).

In a sinking for a well on Viper Island one of the above-mentioned nests of coal was met with, and samples from thence on analysis yielded the following results :—

	Unpicked.	Picked.	
Carbon	50·8	52·3	62
Volatile	2·6	41·4	34
Ash	23·2	6·3	4
	100·	100·	100·

[1] Expedition to Western Yunan *viâ* Bhamo, p. 202.
[2] *Idem*, p. 199.

Although from its lightness and friability this coal, supposing it to be found in quantity, might not prove well suited for employment in marine engines, still there is no doubt that for other purposes it would possess a considerable value.[1]

Nicobar Islands.—The existence of coal in certain islands of the Nicobar group has now been known for many years, and at one time it attracted some little notice. There is every reason for believing, however, that its mode of occurrence is similar to that of the Andamans. Although the rocks in some of the Nicobars are probably not very far removed from those of eocene age, which in Java, Borneo, and Sumatra contain workable and valuable seams, still no such seam has yet been discovered on any of the smaller islands, and it is impossible to say what the interior of the Great Nicobar may or may not contain, as its exploration has hitherto been very partial.

In the year 1845 Mr. Mackey,[2] the Danish Consul at Calcutta, together with two Danes, visited the Nicobars in a schooner commanded by Captain Lewis. The principal object of this expedition was to search for coal, of the existence of which rumours had already reached Calcutta. The journal of Mr. Busch, one of the Danes, shows that the party were successful in obtaining some fragments of coal and lignite. Weathered samples of those which had been found in the sands of the Southern Islands were analysed by Dr. M'Clelland,[3] and his description of some of them suggests the possibility of their being European coal which had fallen from ships, as some of the coal brought at other times from the Nicobars is believed to have been. Be this as it may, Drs. Rink and Hochstetter,[4] and subsequently the writer, obtained more or less coaly or carbonaceous matter *in situ* in the sandstones of these islands. Dr. Rink,[5] who was geologist on board the Danish corvette *Galathea*, found coal on Little Nicobar, Trice, Milu and Kondul, and fossil resin resembling amber on Milu. He states that the nests of brown coal occurred without any order, sometimes in the sandstone and sometimes in the shale, and appeared to be derived from drift wood. Dr. Hochstetter obtained similar samples *in situ* on the islands of Track, Kondul, and the south side of the Great Nicobar. On the strand at Pulo Milo he picked up pieces of laminated coal on the beach, such as come from seams; but these, he thinks, may have fallen overboard from the steamer *Ganges*, which accompanied the *Galathea*.

[1] Jour., As. Soc., Bengal, Vol. XXXIX, p. 236.
[2] Selections from Records, Government of India, Vol. LXXVII, pp. 20, 21.
[3] *Op. cit.*, p. 28.
[4] *Op. cit.*, pp. 127, 128.
[5] *Op. cit.*, p. 221.

In conclusion it may be said[1] that so far as examination has yet gone there is no ground for believing that a valuable deposit of coal exists in either the Andaman or Nicobar groups of islands; at the same time it is just possible that such may yet be found.

Peat.—From time to time propositions have been made in reference to the employment of peat as fuel for Indian locomotives. The sole objection, however, to the scheme, and one which cannot but be accepted as valid, is that, in so far as the northern part of the peninsula is concerned, true peat does not exist, and the evidence available points to the vegetable accumulations, which have been described as peat, being both in quality and quantity wholly unsuited to the purpose of manufacturing into an economical fuel.

It has sometimes even been questioned whether the term "peat" is strictly applicable to the deposits formed at high elevation in the Nilgiris in Southern India; but as will be shown the term is, in this case, quite an appropriate one. This peat has attracted some particular notice, and the following is a *résumé* of all available information on the subject.

Madras: Nilgiris.—A very elaborate paper with discussion on the subject of the employment of the peat of the Nilgiris in a condensed, as distinguished from compressed, form for fuel on Indian Railways is printed in the Journal of the Society of Arts.[2] Colonel Romaine Wragge, the author, expresses a confident opinion as to the abundance of peat in the Nilgiris, and the possibility of its being brought to the ports of Madras and Bombay and being sold there at a price considerably less than that of coal. That the swampy accumulations of vegetable matter which occur there have yielded a fuel for local purposes is amply attested by various writers[3] on the Nilgiris. Indeed it is a fact sufficiently notorious that turf is largely employed for burning, and is sold at a moderate price; but there are no data available as to its working power in locomotives, and until by analysis and actual practical trial it is shown to be equal to Irish or Canadian peat, it seems to be rather premature to apply to it the statistics referring to the latter. However, samples cut into prismatic pieces, which were sent to Dr. Percy by Dr. Cleghorn, though not analysed, were according to the former similar to the marketable peat of England.[4]

Mr. W. T. Blanford, who is quoted by Dr. Percy, has stated that the peat of the Nilgiris is only found on the part of the hills above 6,000

[1] Jour., As. Soc., Bengal, Vol. XXXIX, p. 28.

[2] Jour., Soc. of Arts, Vol. XIX, 1871, pp. 201 and 266.

[3] Cleghorn, Dr. Forests and Gardens of South India. Lond. W. H. Allen, 1861, pp. 87, 162, 178.

[4] Percy's Metallurgy, 'Fuel,' 1875, p. 204.

feet in a temperate climate where both the fauna and flora show affinities to those of the palæarctic region, and differ entirely from those of Bengal. Dr. Cleghorn says that the general appearance of the bogs in the Kunda mountains resembles that of those which occur in Europe, and although the species of plants from which they are formed are not identical, the same genera are often present in both, as *Scirpus, Carex, Parnassia, Utricularia;* others being absent, as *Erica, Erichora,* &c.; but *Sphagnum* prevails very extensively in these upland marshes of the east as well as in the bogs of Europe. The prevalence of the idea that true peat does not occur in the tropics doubtless accounts for the unwillingness of some to apply the term to this Nilgiri turf; but it is clear from the above that it is true peat, and that at the same time it is scarcely true to speak of it as occurring in the tropics notwithstanding the latitude, since the altitude at which it is formed removes it from a tropical into a temperate climate. It is stated that in some cases bogs which have been opened up have been completely washed down the mountains by heavy monsoon rains.

Although there are no estimates as to the extent of these bogs, still by all competent to form an opinion it seems to be admitted that they are numerous and include a vast supply of fuel. On the western side of the hills, sunny days suitable for drying the turf are not of frequent occurrence, but this objection does not apply to the eastward according to Dr. Cleghorn.

As to the cost of production, Dr. Cleghorn states that the retail cost of a cart-load of turf at Utakamund is Rs. 2 to 2½. Another statement is that a cart-load weighing 1,000 pounds can be obtained at the bog for 8 annas.

A table by Colonel Wragge represents his estimate of the saving which would be effected by using peat instead of coal on the four principal peninsular lines, excluding the East Indian, the figures of coal consumption being taken from returns of 1867. The sum so saved is put down at £124,033 per annum; but his calculations depend principally upon the question as to the cost of transport, which can only be discussed by those with local knowledge, and they alone can say whether 6d. per ton per mile for carting down the hills is a practicable estimate.

In a second table the cost of the peat at the Nilgiri depôt is put down at 10s. per ton, and this, it is said, could be carried from Beypur to Bombay by coasting vessels at a total cost when landed of £2 per ton. By way of comparison the price of English coal is stated to be £3-15-0 per ton; but this is certainly an excessive price. Even in another part of his paper (p. 202), the average cost of European coal landed in Bombay

for the use of the railways is stated to be only £2-2-8, and at the present time coal can be obtained in Bombay for about Rs. 17-8 per ton.

Lower Bengal.—There are in the neighbourhood of Calcutta and in other parts of Lower Bengal two kinds of vegetable accumulations, to which, in the absence of a more suitable name, the term Peat has been applied.

The older of these occurs in the alluvium at varying depths below the surface, and excavations about Calcutta frequently lay it bare. A section in a tank at Sealdah, described and figured by Mr. H. F. Blanford,[1] was as follows :—

Fine sand	20 feet.	
Loam passing into clay		
Peat with tree stumps	1 foot.	
Clay with sand and tree stumps	10 feet.	
Lowest trees seen	15 feet.	
Blue clunchy clay with roots of trees . . .		
Black carbonaceous sand		46 feet.

The peat bed of the above section is traceable over a wide area on both sides of the Hugli river, but its depth from the surface, or in reference to the sea level, varies considerably. Since the Sundri trees, *Heritiera littoralis*, to which the stumps belonged, died, there must, it is concluded, have been a subsidence of 18 feet at Sealdah.[2]

For our present purpose it is not necessary to give any further particulars as to the distribution of this deposit. Generally speaking it appears to be too impure to be of much use as a fuel. The following analysis by Mr. Prinsep[3] of some which was dug up from 30 feet below the surface at the Chitpur lock-gates does not distinguish between the aqueous and combustible volatile constituents :—

Volatile matter, principally aqueous	62·0
Fixed carbonaceous matter	16·7
Red ash	21·3
	100·

Even were there any prospect of its yielding a good fuel, it could not be quarried by open workings to any extent, and mining in a wet soil, such as that beneath Calcutta, could certainly only be effected at an expense far greater than the return.

[1] Jour., As. Soc., Bengal, Vol. XXXIII, p. 157.
[2] Procdgs., As. Soc., Bengal, 1866, p. 81.
[3] Jour., As. Soc., Bengal, Vol. II, p. 435.

This bed of peat was found by Dr. Falconer to contain the seeds of *Euryale ferox*, a plant which was not known to occur nearer than Dacca.[1]

The other variety of peat is forming at the present day in the bottoms of *jheels*, principally from the accumulation of the stalks of wild rice, *Oryza sylvestris*, with which the decayed remains of *Valisneria, Nymphea*, and other plants are sometimes found, but the bulk of the deposit is derived from the rice. It is sometimes used as a manure, for which purpose it is well suited, but it is not likely to afford a useful fuel.[2]

Oudh: PERTABGURH.—Attention was drawn by Major Ouseley[3] some years ago to the occurrence of a black carbonaceous deposit in the *jheels* of Oudh, which it was thought might serve as a fuel. Some experiments appeared to show that it had, when used in locomotives, a greater heating power than wood. The following assay by Mr. Tween of a sample which was forwarded for examination indicates a very poor fuel, the heating power of which was slight, since the fixed carbon did not amount to one-sixth of the whole weight:—

Fixed carbon	16·5
Volatile (including water 13·3)	48·
Ash	35·5
	100·

Kashmir.—A sample of peat from Kashmir, obtained by Dr. Falconer, was analysed by Dr. Percy.[4] It was brown, crumbly, and somewhat like coarse cut tobacco in texture. It contained the remains of aquatic plants, but none of mosses. The included water amounted to 10·40 per cent.

Carbon	37·15
Hydrogen	4·08
Oxygen	23·48
Nitrogen	2·02
Ash	33·27
	100·

From a comparison of the amounts of fixed carbon, this substance ought to have about twice the heating power of that from Oudh.

North-west Provinces.—Traces of true peat are said[5] to exist at Bhim Tal, near Naini Tal, but the deposit there must, from the nature

[1] Hooker's Himalayan Journal, Vol. II, p. 341.
[2] Jour., As. Soc., Bengal, Vol. XXIII, p. 400.
[3] *Op. cit.*, Vol. XXXIV, pp. 85, 86.
[4] Percy's Metallurgy, 'Fuel,' p. 205.
[5] Atkinson, E. T. Economic Geology of Hill Districts of North-Western Provinces: Allahabad, 1877, p. 32.

of the case, be so limited in extent as not to have any great commercial value.

Nepal.—Beds of an impure peat are of frequent occurrence in Nepal, according to Mr. H. B. Medlicott.[1] They were observed in the gullies close above the Katwaldar gorge, and near the surface of the uplands north of Katmandu, not being confined to the margins of the valley. As contrasted with the peats of Kashmir, these deposits are thick, and the quality is good enough to afford a fuel which is largely employed for brick-burning.

Assam.—Similar *jheel* deposits to those described above as occurring in Bengal are also found in Assam, as might be expected. A sample forwarded to the Geological Survey office from Nazira on examination by Mr. Tween gave the following poor results:—

Carbon	13·4
Volatile (including moisture 13·6) . . .	34·2
Ash	52·4
	100·

At Phenchuganj, in Silhet, a deposit of so-called peat was discovered by the late Dr. Barry in 1863. It was said to burn well.

Burma.—Considerable deposits of peat are believed to exist in the higher valleys of the Salwin and Irawadi rivers; but particulars regarding them are scanty. Such lakes as the Nongyang, near the Patkai range, in Upper Burma, recently described by Mr. S. Peal, may be expected to have in connection with them large peaty deposits.[2]

Petroleum.—Petroleum, so far as our knowledge goes, is wholly absent from Peninsular India; supposed discoveries have indeed been reported from time to time, but these, on being subjected to strict examination, have proved to be fallacious. The most notorious of these cases occurred at Khona Oopalapad, in the Madras Presidency; but there the supposed petroleum proved to be only a substance derived from the accumulated droppings of bats.

Passing from Peninsular India to the extra-peninsular countries where the rocks belong to formations closely related to those of Europe, we meet with several regions where the strata yield more or less abundant supplies of petroleum, some of which are of considerable economic importance. The nature of this product varies at different localities; in some it consists largely of the lighter hydrocarbons, such as naphtha; in others the heavier and less readily combustible varieties

[1] Records, G. S. I., Vol. VIII, p. 99.
[2] Jour., As. Soc., Bengal, Vol. L, Pt. II, 1881, p. I.

prevail, and these, on exposure to the atmosphere, become oxidised and change into the condition of asphalt.

There can be little doubt that the formation of petroleum is intimately though obscurely connected with the presence of salt, otherwise it would be difficult to account for the simultaneous occurrence of petroleum and brine springs which has been observed in India as well as in Pennsylvania and Virginia.

Singrowli.—According to Mr. W. Roberts,[1] Mr. Osborn, of the Opium Department, discovered iron sulphate with exudations of petroleum at the Umlah Ghât, in the year 1837; but the latter not in sufficient quantities to be of any use. Nothing has since been heard of this discovery.

Alwar.—TIJARAH, Lat. 27° 56′; Long. 76° 54′.—Close to Tijarah, in the Alwar State, and about 30 miles north of the city, the discovery of a bituminous deposit was reported in the year 1874. Its mode of occurrence was thus described by Dr. Ffrench Mullen, Surgeon to the Agency.

It was found in two fields, which are about 20 feet above the level of a road which runs east-by-south to the Ladloara fort. The substance was first turned up by the plough and was found to be combustible. It lay in patches in the soil of from 3 to 4 inches thick, and at an average depth of 3 inches from the surface. Trenches cut across the fields did not prove the existence of a greater thickness anywhere.

Samples of this substance, which were forwarded to the Chemical Examiner to the North-West Provinces and Oudh, yielded 25·56 per cent. of bitumen and 3·72 of fixed carbon. Other samples forwarded to the Geological Survey office yielded from 30 to 60 per cent. of combustible matter.

According to native tradition, the spot had been the site of a *bathan* or cattle village. It was suggested at the time that the deposit was due to infiltrations from animal and vegetable refuse; but the locality does not appear to have been visited by any one qualified to give a definite opinion. It seems probable that a true bitumen was formed by the alteration of the *cellulose* of an accumulated mass of vegetable matter, in contact with a saliferous soil. The facts do not justify the conclusion that the discovery had any real value, and it is chiefly in consequence of its having given rise to a considerable amount of official correspondence that it is mentioned here.

Cutch.—Mr. Wynne states that some friable brown shales in the sub-nummulitic and next succeeding beds contain small resinous and black

[1] Selections from Records, North-West Provinces Government, new series, Vol. III, p. 152.

bituminous lumps which are burned in the native temples as incense. It is called *Bhut khana* or spirit food at Mohurr, where it is found, and it also occurs at Julerai and Lukput. To the eastward of the latter place it was observed in small quantities in tertiary shales, which belong to a horizon slightly above that of the nummulitic group. No mineral oil appears to have been discovered as yet in Cutch.[1]

Balochistan.—According to Captain Hutton, at the sulphur mines of Suni (Sunnee), 40 miles from Bagh, in Kachi, petroleum drops from the roof into a small hollow. It is, as will be again referred to in the description of the sulphur, boiled together with the impure varieties and refuse of the mine and forms a dark-coloured brimstone. Reports of the existence of petroleum in the Mari country have been at several times recorded, but definite information on the subject is not available.

Afghanistan.—In Afghanistan it is believed that there are several localities where bituminous products occur, as they are commonly sold as drugs in the bazaars of that country. According to Captain Hutton,[2] a mineral pitch called *Mumiai* by the natives, and which is used for external application, is found in the Shah Makhsud range. A substance supposed to be this same *Mumiai*, otherwise called Rock Chetny, which was obtained by Lieutenant Conolly as an exudation from a fissure in a rock in Ghazni, was analysed by Mr. Piddington,[3] who concluded, in spite of its savoury name, that it was composed of the excreta of birds, more probably of bats, mixed with salts of lime. There was no trace of bitumen or sulphur. In fact, the substance was no doubt similar as regards its origin to that which many years afterwards, as already mentioned, attracted so much notice in the Madras Presidency.

Panjab.—In writing an abstract of the available information on the subject of the petroleum and asphalt of the Punjab, there is this somewhat unusual feature for India, that it has already been done on an extended scale by a specialist, Mr. B. S. Lyman,[4] a Mining Engineer, who was brought out by the Government to report upon the petroleum-yielding districts of India. His researches did not extend beyond the Punjab. His conclusions, it should be said, fully confirmed the opinions already expressed by Dr. Oldham and Mr. A. B. Wynne of the Geological Survey.

As Mr. Lyman appears to have consulted all or nearly all the available authorities, the list of whose publications will be found at the end of this

[1] Mem., G. S. I., Vol. IX, p. 89.
[2] Cal. Jour., Nat. Histy., Vol. VI, p. 601.
[3] Jour., As. Soc., Bengal, Vol. IV, p. 696.
[4] Report on Punjab Oil Lands: Lahore, 1870.

volume, it will be less necessary to quote from previous writings here than it is in the cases of other deposits. One exception must be made, as from Mr. Wynne's last report it will be necessary to draw our information regarding the geology.

Mr. Lyman's general conclusion was that by properly opening up the known localities there was a fair likelihood of obtaining about 100 gallons of oil a day for eight years, after which the supply would probably fail. The accumulated asphalt, he thought, might yield 100 gallons a day for three or four years, so that in all twelve years' supply would be forth-coming for the gas works at that rate of consumption, after which the railway to Rawalpindi might make other gas material available.

Since Mr. Lyman's report was written, the gas works have come into full operation, and the Superintendent, Mr. C. H. Blackburn, has kindly forwarded a note, from which we learn that the total quantity of oil collected during the past year, 1880, was 2,850 gallons, at a total cost when brought to Rawalpindi of Rs. 1,317-0-3, or 7 annas 4¾ pie per gallon. The details will be found on subsequent pages under the head of Barra Kutta (Jaba) and Gunda (Fathejung), where alone the springs are at present worked. The average production of gas per gallon of oil during the year was 320 cubic feet, with an illuminating power equal to from 14 to 15 standard candles.

It may be of interest to add that an experimental trial of the Pindadun Khan or Khewra coal, as a substitute in the manufacture of gas at Rawalpindi, has recently been made by Mr. Blackburn. The gas was produced at the rate of 10,900 cubic feet per ton of coal, and in lighting power it was equal to 12½ standard candles. The amount of sulphur was excessive, and the smell resulting from its presence was very pungent in the unpurified gas. The residue in the retort was a fine ash which did not cake.

Shahpur District: Duma, Lat. 32° 39′; Long. 72° 17′ 30.″—At this locality there are five spots where tar or asphalt exudations occur on a sandy bed not more than 5 feet thick. Four of these spots are situated on the Wudda Duma, within 40 yards of the junction of two streams which form it; the fifth, 14 yards above that point, on the Nikka Duma. The amount of liquid tar seen at all these places put together did not exceed half a gallon in all. Mr. Lyman's report as regards this place was unfavorable, and he discouraged the idea that boring would increase the yield to a profitable extent. He compares the extent of the deposit to that of the small beds of lignite which consist of the mineralised remains of a few plants. Duma is 3½ miles north of Kabuki and 77 miles south-west by south of Rawalpindi.

CHINNUR, Lat. 32° 37′ 30″; Long. 62° 12′.—The tar at this locality issues at three spot,—sone in a limestone, the others in brownish grey sandstone. At the most eastern of these there was only about a tea-spoonful of tar; at the middle, half a pint; and at the western, the merest trace of scum.

The deposits from whence these exudations are derived do not, in Mr. Lyman's opinion, exceed a few feet or perhaps inches in extent. It would, he states, be folly to attempt boring. This locality is 83 miles south-west of Rawalpindi and 2½ miles north-west of Murdwal.

HANGUCH, Lat. 32° 38′ 30″; Long. 72° 14′ 30″.—The tar issues from a brownish grey sandstone bed within a few feet of its base, and the two springs, which are 25 feet distant from one another, come from layers about 6 feet apart. The one from the upper layer is the larger, but the whole yield of both is hardly a pint.

As the sandstone which yields it is well exposed at the springs, the bituminous matter from which it comes must be of very limited extent. It would therefore be unwise to make borings, but the steadiness of the dip indicates the points where borings should be made were it decided to prove the bed at greater depths. This locality is 81 miles west by south of Rawalpindi and 2½ miles north-west of the village of Dhuddow.

Jhilam District: SADIALI.—This locality is only known by native report. Mr. Lyman's guides failed to point it out to him. The amount of tar is said to be small. The position is 90 miles south-east of Rawalpindi, 7 miles south-east of Lawa, 4 miles south-east of Nara, and 2 miles east of a salt chowki.

SULGI, Lat. 32° 30′; Long. 72°.—This locality, which is situated near Amb, does not appear to have been visited by Mr. Lyman, but the deposit which is described by Mr. Wynne seems to be small and of no commercial value. Tar was found exuding from a brown tertiary sandstone above the nummulitic limestone.

Bannu District: BARA KUTTA, Lat. 32° 51′; Long. 71° 44′.—There are in this vicinity three or four springs within a distance of 60 yards along the western bank of the Bara Kutta and at about the water level. The oil comes from fissures in a gray limestone rock through a space of about 100 feet in thickness, and the main spring comes from about 100 feet below the top of the lime rock. The oil at first is dark green in colour, but quickly becomes dark brown or black and tarry. The main spring is some 6 feet long and a foot or two wide and quite shallow; the others are smaller.

The natural yield here Mr. Lyman estimated at three pints daily, and he considered the locality of sufficient promise to recommend boring;

the bed is continuous with that at Chota Kutta and may possibly be oil-bearing throughout. The dip is steep and reversed, so that to reach the bed at 840 feet distance, it is estimated that a boring of 1,000 feet deep would be required, though a boring close by would traverse the bed for 200 feet. These springs are situated 1¾ miles south of Jaba, 10½ miles south-east of Kalabagh, and 95 miles south-west by west of Rawalpindi.

Mr. Blackburn's recent account, which has been referred to above, is as follows. At Jaba there are five springs, in each of which the oil rises with the water and is skimmed off the pools. A small bore-hole, 4 inches in diameter and 12 feet deep, yields about one gallon a day. The total yield from this locality was 1,400 gallons in 1880.

CHOTA KUTTA.—The mode of occurrence here is similar to that above described as regards the rock. The fissures from which the oil exudes are situated in a thickness of about 100 feet of the limestone rock, and the main spring comes from about the centre. There are three oil springs on the left or eastern side of the stream near the water's edge and a fourth on the western side. The oil in the springs rises with water and floats upon it. At two or three of the larger springs holes have been dug, say a foot and a half across and two feet deep.

At the main spring gas continually bubbles up. The estimated yield is at least three quarts a day. This suggested that borings should be made to test these beds. A large quantity of gypsum, which includes some sulphur, occurs near the springs. From both these localities, Bara and Chota Kutta, the cost of transport for each camel-load to Rawalpindi would amount to about Rs. 1-8. Chota Kutta is 1½ miles south by west of Jaba, 10 miles south-east of Kalabagh, and 95 miles south-west by west of Rawalpindi. Mr. Lyman gives a long list of the authorities who have described this locality.

BASTI ALGAD, Lat. 32° 33′ 30″; Long. 71° 22′.—The locality known by the above name is situated 10½ miles south of Isa-khel and 124 miles south-west by west of Rawalpindi, according to Mr. Lyman, who calls it Aluggud. The asphalt deposits are said to extend in spots for about a quarter of a mile along the east side of the brook, and amount in all to about 350 cubic yards. They are somewhat impure and the quantity accumulated would weigh about 550 tons. The liquid tar perhaps amounted to 100 gallons. As there was no sign of oil except near these deposits, it is concluded that the bed is not bituminous for any great distance. It is recommended that a boring be made close by, which, owing to the thickness of the oil-bearing beds, might be expected to prove successful. Mr. Lyman thought that the rock containing the oil was of carboniferous age Mr. Wynne[1] has, however, identified them as being towards the top of the

[1] Mem., G. S. I., Vol. XVII, Part II, p. 60.

upper part of the ceratite group and they are therefore triassic. The oil or asphalt might be sent down the Indus by boat or up it to Isa-khel, and thence by road to Rawalpindi, a distance in all of 145½ miles.

Kohat District: PANOBA, Lat. 33° 36′; Long. 71° 58′.—The springs at this locality, three in number, are situated 67 miles due west of Rawalpindi. The oil comes from fissures in a steeply inclined nummulitic limestone. The daily yield from the three is estimated at half a gallon. It is more inflammable than the oil at Gunda which is mentioned below. Borings are suggested. The distance by road to Rawalpindi is 87 miles.

Lieutenant, afterwards Sir Alexander Burnes[1] mentions the existence of petroleum springs near Kohat, the oil from which was used for burning by the natives.

These springs appear to have been visited by Lieutenant Wood[2] when on his journey to the Oxus. The oil, which he calls naphtha, issued from five springs and yielded, he estimated, five gallons a day. He alludes to the manufacture of sulphur here.

Rawalpindi District: DULLA, Lat. 33° 37′; Long. 72° 35′.—At this locality, which is situated 38½ miles due west of Rawalpindi, and 16 miles west-north-west of Futtehjang, there is no liquid oil exposed, the nearest approach being some asphalt melted into tar by the sun's heat. The amount of accumulated asphalt is about half a cubic yard. Borings here do not promise success and the inaccessibility of the locality is a drawback. The rock containing the bitumen is believed to be nummulitic limestone, the same as that at Bara Kutta, &c.

JAFIR, Lat. 33° 33′; Long. 72° 35′.—Some borings made here revealed a trace of oil, but none is now to be seen at the surface.

BOARI, Lat. 33° 34′ 30″; Long. 72° 36′ 30″.—This locality is 28½ miles west from Rawalpindi as the crow flies. The quantity of oil seen here is insignificant; there is an accumulation of about six cubic yards of asphalt and some earth saturated with bitumen. The rock, which is nummulitic limestone with a steep dip, appears to be only very locally bituminous, and boring is not recommended. The earth would afford a scanty supply of oil and gas, but would perhaps not be worth the cost of carriage.

CHURHUT, Lat. 33° 35′; Long. 72° 37′.—The oil-well here is situated 28 miles west of Rawalpindi and 5½ west by north of Futtehjang. The rocks are of nummulitic age. The yield of oil is small. Digging operations were carried on in 1869 by Mr. Fenner, and the hole was said to yield half a gallon daily. There is an accumulation of about 15 cubic

[1] Jour., As. Soc., Bengal, Vol. II, p. 267.
[2] Personal Narrative, p. 144.

yards or 19 tons of impure asphalt. It is not considered likely that borings would be successful.

GUNDA OR SUDKAL, Lat. 33° 34′ 30″; Long. 72° 41′.—These wells are situated about 23 miles slightly south of west of Rawalpindi and 2½ miles north-west of Futtehjang. The rocks here are nummulitic also, with considerable accumulations of more recent deposits resting on them. Oil-wells were dug here first in 1866 by Mr. Fenner, and one of them, known as the 'main well,' yielded at first about five gallons a day; when deepened to 35 feet it yielded at first 25 gallons, and when a boring was made to a depth of 75 feet from the surface the first day's yield was 50 gallons. Between the 8th of April and 22nd October 1870 the amount of oil collected was 1,963 gallons. Mr. Lyman estimated that about 1,000 gallons more might be expected, after which the yield would be insignificant. The amount of asphalt on the surface was estimated to be about 19 tons, which would give about 11,000 cubic feet of gas. Various borings were recommended by Mr. Lyman to further develop the yield. Mr. Wynne[1] has also described this locality.

Mr. Blackburn (*in epist.*) states that at Gunda there are now five borings and one well in use. The diameter of the borings is four inches and the depths vary from 68 to 120 feet. The oil is obtained by passing down dipping tubes, but the process is slow and tedious and the yield is small. The quantity obtained in the well is minute, and is got by skimming the water every second or third day. The total average annual yield now exceeds 2,000 gallons.

LUNDIGAR, NEAR MURAT, Lat. 33° 30′; Long. 72° 55′.—Here there are two spots at a distance of a quarter of a mile from each other; at one earthy asphalt is found, at the other a small quantity of oil. The rocks are nummulitic sandstones with a high dip. Boring does not seem likely to yield any large supply, as the bituminous deposits have all the appearance, like so many others, of being exceedingly local.

BASALA, Lat. 33° 30′ 30″; Long. 72° 57′.—Ten miles and a half south-west by south from Rawalpindi and one mile and three quarters east of Murat. The rocks are probably of the same age as those at Gunda. The yield here is estimated at a gill a day; the oil rises drop by drop through shallow water. Boring is not recommended as the bed of rock at its outcrop gives no evidence of the existence of anything but a most limited source of this oil.

CHIRPAR, Lat. 33° 30′ 30″; Long. 72° 2′.—Three-quarters of a mile south-west of Musrot and eight miles south-west of Rawalpindi; a sort

[1] Records, G. S. I., Vol. III, p. 73.

of natural paraffine forms stalactites in a cave on the Chirpar mountain. The deposit is too small to justify any expenditure.

RATA OTUR, eleven miles north-east of Rawalpindi. The rocks are nummulitic limestones from fissures in a bed of which the oil issues to the extent of half a pint a day or even less. There is about half a ton of impure asphalt on the ground. Mr. Lyman, notwithstanding that the produce was so small, recommended an experimental boring of not more than 100 feet in depth.

Hazara District.—In the Serra mountains, according to Captain Abbott, there are three springs, one yielding bitumen, another sulphate of iron, and the third a mucilaginous substance resembling the pulp of an orange and having a pleasant odour. This is probably paraffine. Torches are made of the asphalt, but the use of the other substance was not known.

Kumaun.—Bitumen is said by Captain Herbert[2] to exude from the crevices in a limestone rock on the summit of the range between the Sarju and Ramganga. It is used by the natives as a medicine, and from its high price it is concluded that it is not abundant. A similar exudation was subsequently referred to by Mr. Lawder in a paper on the mineral statistics of Kumaun.[3] Some remarks were made at the time as to the appropriateness of the term *salajit*, which is the usual name for alum, but *kala* (black) *salajit*, so called in Nepal, is, according to Dr. Campbell, a bituminous substance.[4]

Assam.—The petroleum of Assam has attracted notice for many years. Hitherto attempts to work it have not been very successful as commercial speculations; but the failure seems to be due to causes other than those which could be attributed to any defects in the quality or quantity of the substance. The consensus of opinion by geologists, and others competent to express judgment on the subject, is favourable to the prospect of a profitable industry being possible when the means of communication shall have been improved, and when other difficulties which have hitherto operated prejudicially shall have been removed. Some of these latter affect all mining enterprises in India and have been sufficiently alluded to elsewhere.

The occurrence of petroleum in Assam has been most distinctly shown to be intimately connected with the presence of coal-bearing rocks. According to Mr. Mallet there is no recorded instance of petroleum having been

[1] Jour., As. Soc., Bengal, Vol. XVI, p. 1137.
[2] As. Res., Vol. XVIII, p. 230.
[3] Records, G. S. I., Vol. II, p. 89; Vol. IV, p. 2.
[4] Jour., As. Soc., Bengal, Vol. III, p. 483.

found in Upper Assam save within the limits or in the immediate vicinity of the coal-fields. Marsh gas commonly occurs with the petroleum, and there appears to be more than chance in the fact of the contiguity of saline and petroleum springs. It has been observed to be the case in the Punjab and Burma, as well as in Assam.

For particulars regarding the petroleum of Assam an already published account by Mr. Mallet[1] has been the chief source from which the following abstract has been prepared. Mr. Mallet has shown that for commercial or leasing purposes the oil-springs, or, as they are locally called, '*pungs*,' may be thus classified :—

1. Those in the Tipam Hill north of the Dihing ;
2. Those in same range between the Dihing and Disang;
3. Those of the Makum coal-field south of the Dihing between the Dirak and Tirap rivers ;
4. Those to the east of the Tirap.

Supkong in the Bari Dihing.—Two petroleum springs were discovered here near the outcrop of a seam of coal in the year 1825 by Lieutenant Wilcox.[2] Neither the coal nor the petroleum were used by the Singhphus. On the surface of the liquid mud at the springs, green petroleum floated. The place was a 'lick' much resorted to by cattle and wild animals.

Namrup Pathar.—Several petroleum springs were discovered by Major White[3] in 1837 on the Namrup river, in the country of the Singhphus. These had been previously unknown to Europeans and were not then much used by the inhabitants. In Dr. Griffiths' private journals[4] allusion is twice made to these springs. They occur in four different places all close to the Pathar, three on the low hill to the south and one on the Pathar itself. The discharge varies in quality from a thin greenish fluid to a bluish grey opaque one, which is somewhat thick. The quantity yielded by the springs of the latter character is considerable ; on the surface of all an oleaginous, highly inflammable fluid collects as a thin film.

Namchick Pathar.—Captain Hannay[5] describes the occurrence of petroleum close to a coal-seam in this place, near the mouth of the Namchick river. White mud-mixed with petroleum is said to be

[1] Mem., G. S. I., Vol. XII, p. 356.
[2] As. Res., Vol. XVII, p. 415.
[3] Jour., As. Soc., Bengal, Vol. VI, 1837, p. 243.
[4] Calcutta, edited by Dr. J. M'Clelland, pp. 60, 117.
[5] Jour., As. Soc., Bengal, Vol. XIV, p. 81.

thrown up in certain basins or pools intermittently and with considerable violence.

NAMDANG RIVER.—Petroleum rises in at least two spots in the bank of the Namdang river, in the Makum coal-field, a little below its exit from the hills.

MAKUM, Lat. 27° 15'; Long. 95° 44'.—In 1865 the petroleum springs in the Makum coal-field were visited by Mr. H. B. Medlicott, who stated that though their discharge was small they were the most promising which he had seen, but nothing had then been done to facilitate it. The gas was so abundant and so continuously poured forth that when lighted it flamed without intermission. This, coupled with the fact that there was no water discharge, led Mr. Medlicott to recommend boring in order to fairly test the supply.

This was done in 1867 by Mr. Goodenough, a member of the firm of Messrs. Mackillop, Stewart and Co., of Calcutta. Oil was struck at 118 feet, and it immediately rose 74 feet, or to within 44 feet of the surface. About 300 gallons were drawn, after which the yield became irregular; altogether about eight holes were put down. The return from No. 5 hole was as follows :—

Table showing when the blows of oil commenced, the time the oil continued running, and quantity of oil given.

Date, 1868.	Commenced to run.	Days and hours running.	Gallons per day of 24 hours.	REMARKS.
January 8th ...	9 A. M. ...	6 days 15 hours	530	Stopped gradually.
„ 16th ...	11 „ ...	13 „	1,500	1,500 gallons in 12 hours (very strong blow).
„ 17th ...	11 „ ...	14 „	2,100	2,100 gallons in 14 hours (very strong blow).
„ 20th ...	Midnight ...	9 „	500	500 gallons in 9 hours.
„ 21st ...	10 A. M. ...	20 „	480	480 gallons in 20 hours.
„ 23rd ...	11 „ ...	1 day 13 „	300	300 gallons per day (ran slowly).
„ 27th ...	9-30 „ ...	23½ „	300	Do. do.
„ 29th ...	9-30 „ ...	6 days 15 „	250	Running very slowly.
February 5th ...	9 „ ...	19 „	500	500 in 19 hours.
„ 7th ...	9 „ ...	2 days	700	
„ 13th ...	2 P. M. ...	19 „	1,400	In 19 hours 1,400 gallons.
„ 16th ...	9 A. M. ...	1 day 6 „	1,600	1,600 in 30 hours.
„ 27th ...	11 „ ...	1 „ 5 „	900	In 29 hours.

Table showing when the blows of oil commenced, the time the oil continued running, and quantity of oil given.—concld.

Date, 1868.		Commenced to run.	Days and hours running.	Gallons per day of 24 hours.	Remarks.
March	2nd ...	9-30 A.M. ...	1 day 6 hours	1,700	In 30 hours.
"	7th ...	9 " ...	2 days	3,000	3,000 in 48 hours.
"	11th ...	9 " ...	1 day 11 "	3,500	In 35 hours, very strong—burst pipes.
"	31st ...	10 " ...	31 days 22 "	500 per day.	Valve very little open; to reduce the flow as much as possible.
May	14th ...	6 P. M. ...	60 "	450 per day.	
July	14th ...	11-30 A. M. ...	3 " 22½ hours	400	
"	19th ...	9 " ...	4 " 21 "	550	
"	27th ...	1 P. M. ...	15 "	600	In 15 hours.
"	28th ...	10-30 A. M. ...	3 days 1 ,	700	A strong blow.
August	8th ...	9 " ...	3 "	600	In three hours; very strong flow.
"	11th ...	2 P. M. ...	3 days 10 "	1,500	
"	22nd ...	9-30 A. M. ...	8 "	400	In 8 hours.

After this no record was kept nor was the temperature ascertained at any time. Mr. Hughes, from a paper by whom[1] the above facts are extracted, attributes Mr. Goodenough's failure to make the industry commercially profitable altogether to difficulties connected with transport,

A sample of this petroleum which was operated upon was black, perfectly liquid, and of rather strong odour; specific gravity ·971.

One thousand parts were submitted to distillation, first by the heat of a water-bath, but that being insufficient the oil was then heated by direct fire. It began to boil at 460°F.—

1.	20	parts below	500° F.	
2.	96·5	between	500°—525° of sp. gr. . .	·873
	126·5	"	525°—550° "	·882
	100·0	"	550°—575° "	·892
	133·5	"	575°—600° "	·900
	166·5	above	600° "	·918
	133·5	"	. . . .	·936
	166·5	"	turned solid on cooling.	
	943·0			

There was a small residue of coke.

[1] Records, G. S. I., Vol. VII, p. 55.

The first six portions would do for lamp oil, although of rather higher specific gravity than that of American petroleum.

Nos. 7 and 8 contain solid paraffine, which can be separated for making into candles, and the liquid oil used for lubricating; or, after the first six portions have been distilled off, the whole of the residue in the retort might be used as lubricating oil for machinery.

In the year 1878 application was made to the Chief Commissioner of Assam by a Calcutta firm for a grant in perpetuity or for 99 years of the exclusive right to the liquid and solid hydrocarbons in the Jaipur subdivision in the Lukhimpur district; but although there was much correspondence on the subject the negotiations appear to have fallen through.

Bapu or Babu Bor Pung.—At this locality, which is said to be on the northern side of the Tipam range, the presence of a source of petroleum is evidenced by the soil being saturated with bitumen. The earthy matter in samples forwarded to Mr. Mallet varied from 35 to 80 per cent. The mass appears to be of limited extent.

Chapatoli.—On the western side of the Tipam, near the above-named locality, several 'pungs' are indicated on the Revenue Survey maps. Mr. Mallet considers it probable that some of these may yield petroleum.

Jaipur, &c., Lat. 27° 12′ 30″; Long. 95°27′ 30″.—Close to the Hukanjuri path, about two miles from Jaipur, petroleum exudes from the banks of a stream below the nine feet seam of coal. Other springs in this neighbourhood were mentioned by Colonel Hannay.[1] At Nahor Pung, which is a quarter of a mile distant, Mr. Goodenough, whose operations at Makum have been above described, commenced systematic operations in November 1866. In addition to several hand-borings, a Mather and Platts' steam boring machine was worked here and a hole carried down to 195 feet, but although the presence of gas was proved no successful result ensued. Half a mile further to the eastward, petroleum issues from the sub-Himalayan sandstones.

Disang River, Lat. 27° 8′; Long. 95° 26′.—There are at least two springs in a stream half a mile north of the Disáng. Captain Jenkins[2] mentions that close to the second coal outcrop in the neighbourhood of the Disang, there are several small springs of petroleum from which the oil flowed into the watercourse, and four or five seers weight were collected in a few moments by Captain Jenkins's servants.

Teok River, Lat. 27°; Long. 95° 15′.—On the bank of the Teok river, near the faulted junction between the sub-Himalayan sandstones

[1] Jour., As. Soc., Bengal, Vol. VII, p. 169.

[2] Coal Committee's Final Report, May 1845, p. 115.

and the Disang group, there is a spot where the former are impregnated with petroleum. The coal-measures are believed by Mr. Mallet to be not far beneath the surface here.

SAFFRAI RIVER, Lat. 26° 50′; Long. 94° 57′.—On the banks of the Saffrai, and in another locality not far from his coal quarry, Mr. Bruce has stated that oil springs exist.

TIRUGAON, Lat. 26° 49′; Long. 94° 56′.—Three or four miles south of Tirugaon petroleum exudes in small quantity from the sub-Himalayan sandstones.

TIRU RIVER, Lat. 26.°47′; Long. 94°54′.—At the head of the Tiru Mr. Mallet found petroleum oozing from the coal rocks in four or five places. Where it is most plentiful it issues from a massive sandstone which dips 80° to west 40° north. There is another spring in the same band of rock, about 100 yards distant.

TEL-PUNG ON THE DIKHU RIVER, Lat. 26° 44′; Long. 94° 52′.—At this locality, according to Mr. Mallet, an inverted bed of sandstone, similar to the last, contains inspissated petroleum or asphalt in cracks; in places the rock itself is impregnated with the same.

In certain spots in the adjacent river globules of petroleum rise to the surface at frequent intervals, together with streams of bubbles of marsh gas.

Petroleum and gas issue also from some pyritous and carbonaceous shales which overlie the sandstone; the total thickness of the rocks from which they are given off is more than 100 yards.

HIL JAN STREAM, Lat. 26 °43′; Long. 94° 51′.—Petroleum slowly exudes from between the cracks in the coal of the 2 feet 11 inches seam in this stream.

DISAI VALLEY.—Lat. 26° 30′; Long. 94° 25′.—Two or three hundred yards lower down than the 1 foot 4 inches seam in the Disai, petroleum rises from the bed of the stream in small quantity.

Cachar.—Opposite a place called Siltec, according to Mr. Jones,[1] a stream which runs into the Tippera hills showed signs of petroleum in the sandstones 2 miles from its mouth. Siltec is in all probability identical with a well-known customs chowki called Sialtekh on the Barak river.

Mr. H. Inglis,[2] about the year 1841, communicated to the Coal Committee the fact of the existence of petroleum springs in Cachar.

In a letter to the Superintendent of the Geological Survey in the year 1861, Captain R. Stewart stated that rock oil had been discovered in some hills to the north of Cachar, but the actual locality was not

[1] Gleanings in Science, Vol. I, p. 283.
[2] Cal. Jour., Nat. Hist., Vol. I, p. 562.

indicated. In Dr. Hunter's statistical account of Assam[1] it is stated that petroleum has been discovered on the banks of the Barák and Sarang rivers, but no further information is given, nor are there any fuller accounts of Cachar petroleum available at present.

Burma.—Whether it be true or not, as has been stated, that the exploitation of the rock oils of Upper Burma has been going on for 2,000 years, it is certain that for a considerable period there has been an unfailing supply from this source. Of late years increased facilities for transport and an increased demand have called for a proportionately increased outturn, and as the source of supply cannot be inexhaustible, the time must come, though it may yet be distant, when the yield having reached its maximum will rapidly fall again till it ultimately dwindles to nothing. As compared with Upper or Native Burma, to which the above remarks refer, the discovery, and still more the working, of oil springs in British Burma, except on the very smallest scale, is but in its infancy. It is probable, however, that in the islands off the coast of Arakan the natives have collected oil to a limited extent for their own purposes for a long period, but never for export.

It has been asserted that the oil of Upper Burma, commonly called Rangoon oil, differs essentially in character from that of British Burma, Assam, and the Punjab; until comparative chemical examination has proved such to be the case it would be unsafe to accept this view. The real cause of the apparent difference is believed to be largely due to the oxidation and inspissation to which the former is subjected during its long journey in earthen pots and sometimes in bulk in open boats. When first collected it would appear that it often resembles the clearest and most limpid oils of the other localities. Some authors state, however, that it has a creamy consistency. Naphtha contains no oxygen, while asphalt may include as much as ten per cent.

In the following pages an abstract is given of all that is known regarding the occurrence of petroleum in the Arakan and Pegu Divisions of British Burma and in Upper Burma.

The first shipment from Burma was made in the year 1853, and in 1855 a Rangoon firm had a European agent at Yenan-gyoung in Upper Burma, since which time the export trade has much increased.

Arakan Division.—The existence of naphtha and petroleum in Arakan appears to have been first brought to notice by Mr. Bogle, the Commissioner, who in 1841[2] reported to the Coal and Mineral Committee the fact that there were several springs at Paidong, about 5 or 6 miles

[1] Vol. II, p. 370.
[2] Cal. Jour., Nat. Hist., Vol. I, p. 562.

from Ramri. Wells had already then been made at three localities to depths of from eight to ten fathoms, and the yield in three months was about 10 or 12 maunds of naphtha (so called). About the same time Captain Halstead described the method of collecting oil practised by the natives at Cheduba, which he states was only for local use. In the collecting pools, which had artificially raised banks, a green fluid oil first spread itself over the spot where the gas bubbled up. As it extended, its edges exhibited a brown curdled substance resembling "drippings," and a darker brown substance, resembling molasses, collected in patches in this. The two latter substances were used for preserving wood, saturating paper for umbrellas, and sometimes for burning. The curdled substance was sold at the rate of five pots for a rupee; the other at three pots for two rupees. Captain Halstead points out that the outturn was capable of being largely increased.

In the year 1878 the islands of Ramri, Cheduba, and Baronga were visited by Mr. Mallet,[2] who has published a very full account of the petroleum springs. From his paper the following information and the accompanying tables are extracted. The rocks which are oil-producing, as well as oil-bearing, in Ramri and Cheduba islands, are lignitiferous sandstones, which are believed to be of the same age as those which contain petroleum in Upper Burma. In the Baronga islands Mr. Mallet states that, though the oil is the same in character, there is a marked difference in the rocks, as they include neither calcareous nor carbonaceous constituents; but he considers that rocks of the same character as those of Ramri may exist under the sea and contain the original source of the oil. The practice of digging wells has been carried on for many years by the inhabitants. After the harvest in January, and from that time till the rains commence, the villagers have been in the habit of collecting the oil. The wells are of two kinds, first those which are connected with a natural reservoir and in which the oil, with abundance of gas, rises rapidly: secondly, those sunk in saturated rock from which the oil slowly trickles. Mr. Mallet considers it possible that a line of borings sunk at right angles to the direction of the mud volcanos at Tsi Chang, near Kyouk Phyu, might strike a spouting reservoir of great capacity, as the not unfrequent fiery eruptions point to the existence of a fissure in which gas and probably oil with it is stored up. A *résumé* of the observations by Mr. Mallet is contained in the following tables, but by those specially interested reference should be made to his paper, which is illustrated by maps of the locality.

[1] Jour., As. Soc., Bengal, Vol. X, p. 369.
[2] Records, G. S. I., Vol. XI, 1878, p. 207.

Locality.	Character of wells.	Rock in which wells are sunk.	Number of wells.	Depth in feet.	Stated daily yield in bottles.[1]	Color of oil by transmitted light.[2]	Specific gravity of oil at 62° F.
Rámri.							
Tsi Chang . .	Three wells were being sunk in December. Two were only a few feet deep: the third was 20 feet, and had struck oil in small quantity.	Gray clay with sandy and earthy calcareous nodules.	3	20	½	Transparent; color of brandy.	·809
Likmau . .	Well full of water in December; the rice crop was being harvested and oil-collecting had not commenced. Indications of petroleum occur in three other spots near the village. One of these is on the beach, where a shallow well has been sunk which has yielded a little oil.	Sandstone ? .	2	About 18	3		
Menbein . .	See below	Gray clunch .	Several score	5 to 12	0 to 8 or 10	Opaque; reddish brown in thin. layers.	·867
Kángautau .	Ditto	Gray argillaceous sand (disintegrated sandstone?)	12—15	5 to 12	0 to 8 or 10	Transparent; colour of sherry.	·839
Kyauk Galé .	Several pits about 100 yards from the shore on raised beach; they are from a few feet to as many yards diameter and one to two yards deep. Early in January they were filled to within two feet of the top with water, through which gas rose in some of the pits, and there was a faint smell of petroleum. According to the Tehsildar of Konboung, when these pits are emptied of water and dug out to some 15 cubits, they yield some oil. During the rains they get filled up with mud, &c.	Gray clunchy shales.	5 or 6	3 to 6	½, 1 and 4		

Létaung . .	See above	Gray clay .	2?	...	...	Transparent; pale yellow.	·812
	No. 1	...	...	About 25 to surface of oil.	About 30		
	No. 2	...	...	About 40 to ditto.	„ 50		
Cheduba.							
¾ mile south-west of Kanthao Roa.	Wells said to have been first opened about four years ago; they are sunk near the bed of a nála.	Superficial deposits of clay with rounded stones; the rock beneath is probably gray shale.	6—8. At times, it is said, there have been as many as 30.	10 and less.	1 on an average.		
1¼ mile west of Cheduba town.	Mentioned by Captain Halstead (J. A. S. B., Vol. X, 369, 446). It had been destroyed by fire previous to 1841, but the soil around it was "full of the oil."	...	...	...	0 (1841)		
5¼ miles north of Pagoda Hill.	Two wells not far from each other (Captain Halstead.)	...	2	...	60 pots each annually (1841)		
Near north point of island.	Some shallow wells on sea beach.						
North-west of Kama.							
3 miles south-east of Pagoda Hill. At Kaindi Roa.	Mentioned by Captain Halstead. One of these is said to have yielded nearly 200 pots of soil annually, but it is not clear which is alluded to.	...	...	...	Nearly 200 pots annually (1841).		

[1] These figures, in as far as the Ramri group of islands are concerned, are not very reliable.
[2] In cylindrical bottles of 2¼ inches internal diameter. All the oils are dichroic.

Locality.	Character of wells.	Rock in which wells are sunk.	Number of wells.	Depth in feet.	Stated daily yield in bottles.	Color of oil by transmitted light.	Specific gravity of oil at 62° F.
Round Island.							
	There is a spot near the centre of the hilly ground on Round Island, where a smell of petroleum is perceptible in hot weather.						
Flat Island.							
Less than ½ mile south-east of volcanoes	Several pits nearly filled with water in January; gas rises rather copiously from some of them, accompanied by oil.	...	About 6	3 or 4	About 1		
About 1 mile south-south-east of volcanoes.	Pits similar to the above	...	2 or 3	3 or 4	About 1		
Baronga Islands.							
East Baronga; west of Khamangdoeh H. S.	Boring (in progress) on spot where an issue of gas had been observed.	Gray micaceous arenaceous shale.	1	70	0		
Upper part of Ahongjukhi nadi.	Pit in the bed of the nála. A bottle or two only of oil was obtained, and the pit then abandoned. It is now filled with water covered by a light scum of oil; the rock in spots on the brink is impregnated with petroleum.	Gray, rather fine-grained sandstone.	1	9			

A little south of Raung naddi.	Mr. Savage's wells and borings mentioned below.	Gray shale .	3	...	...	Transparent; red	·835
	No. 1	...	...	66	1,000 gallons a day during first week. Later on 120 gallons a day.		
	No. 2	...	...	68	150 gallons a day.		
	No. 3.—A well opened previously to the above which has fallen in, and is now abandoned.	...	...	10 or 12	About ½ *man* (maund) every 3 or 4 days.		
On sea-beach between Raung and Prukhach naddis.	Several shallow pits, which at spring tide are filled with water, through which gas with a little oil rises. At neap tides small quantities of oil are obtained from them.	Grey arenaceous micaceous shale.	12 or more	3 to 6			
North bank of Prukhach naddi.	A pit a few feet deep was sunk in sandstone showing stains of oil. Only a trifling quantity was obtained.	Sandstone.					
Middle Baronga; north point of island.	Artificial pool through which gas with a little oil rises.	Shale and sandstone.	1				
20 or 30 yards south-east of above pool.	Boring (in progress) on Mr. Dawson's grant .	Ditto . .	1	76	0		
About ¼ mile from shore, 1½ miles north-west of Khiweroa.	Small pool through which gas rises. It is said there are other similar pools in the neighbourhood.	Gray clunchy shale?	1				

Locality.	Character of wells.	Rock in which wells are sunk.	Number of wells.	Depth in feet.	Stated daily yield in bottles.	Color of oil by transmitted light.	Specific gravity of oil at 62° F.
200 yards east-north-east of Khiweroa.	Several pools similar to the above. There is a small mud cone here a few yards in diameter, and with a slope of about 15°. The crater is filled with muddy water through which bubbles of gas rise. As the cone is situated in the bed of a nála, it is washed away every rains.	...	4 or 5				
Western Baronga: ½ mile south-west of Mraingu.	Two borings (in progress) on Mr. Dawson's grant.	Alluvium with shale? below.	2	...	...	Transparent; color of dark sherry.	·879
	No. 1	...	...	50	3		
	No. 2	...	...	24	1		
	50 yards to the south of the borings, amidst some rice fields, there is a spot where gas rises, which shows itself during the rains by bubbles. A little saline water issues with the gas, and, owing to the salt, there is a space of some yards around where rice will not grow.						
East coast near south end of island.	Indications of petroleum in three spots at least.						

Krinkwaimau Hills.							
Nagádweng	This name is applied to a natural pool, a few yards diameter filled with muddy water with mud below into which a 15-foot stick can be thrust to the end without difficulty. Gas rises in certain spots in some quantity, and the villagers say that occasionally it is given off in much greater amount.	...	1				
About 250 yards north-west of the above.	Artificial pit partially filled with water, through which some gas and a little petroleum rises.	...	1				
About 70 yards south of above pit.	Bore-hole (in progress)	...	1	32	0		
Near Praira	About 1½ miles went of Nagádweng near the village of Prairoa, there is said to be a pool of the same kind as that at Nagadweng, but of smaller dimensions.						

The importance of this growing industry seems to justify the reproduction in this volume of the above details, as also of the following extract from the same paper :—

" The wells in the southern part of the Eastern Baronga, from which Mr. Savage has recently obtained such encouraging results, are sunk in gray shale which splits with a rather smooth fracture having a slightly unctuous feel. The bedding is very nearly vertical. It appears from the official correspondence on the subject that " Mr. Savage dug two wells about 500 feet apart, and then commenced boring. On the 25th of February he struck oil in one well at a depth of 66 feet; the oil at once rose in the well . . . to a height of four feet; it kept at this level for about seven days, and in that time yielded, Mr. Savage thinks, 1,000 gallons a day; since then the oil has remained in the bore-hole a few feet below the bottom of the well, and 120 gallons or more a day can be dipped out with a dipper. A great deal of the oil escaped from the well through fissures." " The well at its mouth was some 15 feet in diameter, and had been dug with those dimensions to a depth of some 30 feet. Here boring commenced, and had been carried to a depth of 36 feet only, when the workmen were surprised and terrified by a sudden outburst of gas and oil, accompanied by loud subterraneous sounds as of distant thunder. They had only time to make their escape up the ladders of the well before the oil and gas poured in quantities that would otherwise have made their position a very perilous one." " Four days after Mr. Savage struck oil in the second well at a depth of 68 feet under similar circumstances, but the gas appeared stronger, making a great noise. About 150 gallons a day can be dipped out of this well. The oil is clear and liquid; large quantities of gas continually escape not only in these wells, but in all other wells of small depth which are in the locality."

In the Administration Report of British Burma for 1879-80 it is stated that these operations were being carried on under competent professional management and with the best machinery, and it was anticipated that an important staple would in consequence be added to the productions of Arakan.

A company has recently been projected to work the wells at Menbain, in Ramri. Eight wells are being sunk, and it is estimated, according to the prospectus, that these will yield 200 barrels of oil per diem. The flashing point of the oil in its crude condition is 143°. It is proposed to dispose of it at first in this state, the question of refining being left for future determination.

Pegu Divison.—In the Pegu division of British Burma petroleum is known to exist in both the Prome and Thayetmyo districts. The

principal source of information on this subject is contained in Mr. Theobald's memoir on the Geology of Pegu.[1]

Prome District: NAMAYAN, BELOW PROME, Lat. 18° 45′; Long. 95° 18′.—Petroleum has been reported to have been found in the hills south-east of the above-named locality. Mr. Theobald was unable to corroborate the report after a visit, but thought it possible that petroleum might have been found rising up through the younger tertiary rocks on the east bank of the Irawadi. At the same time he considers efforts to discover profitable sources of petroleum should be directed rather to the west bank of the river, as on that side alone do nummulitic rocks occur, and these, it is believed, contain the sources of oil in other parts of Burma, and, as has already been stated, probably also in the majority of the localities in Assam, the Punjab, and Afghanistan.

YENAN-DOUNG, Lat. 18°; Long. 95° 12′.—At this locality, which is 12 miles south-west of Myanoung, a shaft was sunk and the existence of petroleum is testified to by Mr. W. T. Blanford. When visited by Mr. Theobald none was to be seen, but there was a copious evolution of marsh gas from some cracks in the soil close by. The word *Yenan* is Burmese for petroleum.

TOUNGBOJI, Lat. 18° 50′; Long. 95° 8′.—This locality is situated 11½ miles due west of Prome pagoda and 3 miles from a village bearing the above name, on a stream called Mahn-chowng, which falls into the Booyoo. In the "British Burma Gazetteer" the locality is stated to be included in the Padoung township. It is within the area occupied by the nummulitic rocks.

When visited by Mr. Theobald in 1871[2] only one out of four shafts which had been sunk had been successful. This had yielded 2½ viss (nearly 1 gallon) of oil a day at the depth of 35 cubits till it became filled with water by the rains and the supply ceased; subsequently, on the well being emptied and re-opened the flow again commenced. The specific gravity of the oil from this locality is stated to be higher than that from the next locality, Padouk-beng, they being respectively ·909 and ·847.

Thayetmyo District: PADOUK-BENG,[3] Lat. 19° 18′ Long. 95° 20′.—At this village, which lies about 7 miles in a straight line west by north of Thayetmyo, the rocks are earthy bluish sandstones and shales of the newer tertiary series, with low dips. Several shafts were sunk

[1] Mem., G. S. I., Vol X, p. 158.

[2] A full account of Mr. Theobald's opinion and observations on this locality will be found in the Indian Economist, Vol. III, 191.

[3] Or Padouk-ben.

and a small quantity of oil was obtained at 12 feet from the surface, but as this did not increase on their being deepened the work was abandoned.

BHANBYENG,[1] Lat. 19° 24′; Long. 95° 6′.—This locality is situated on the Pwon stream, a tributary of the Irawadi, and at a distance by road of 16 miles from Thayetmyo.

The main shaft here, according to Mr. Theobald, is situated about a mile above Bhanbyeng in a most precarious position on the bank of the stream, which is there undercut. Petroleum fills some joints and cracks just above the shaft. A small sketch of the relations of the rocks shows that it was sunk on the flank of an anticlinal.

According to the "Gazetteer of Burma," the oil from this locality was clear, unlike both that of Upper Burma and of Padouk-beng. The supply appears to have been small. Successive reports on the administration of British Burma give rather conflicting accounts as to the amount of success obtained by those firms who prospected for oil in Thayetmyo. It is believed that nothing is being done in the way of exploitation either there or in Prome at present.

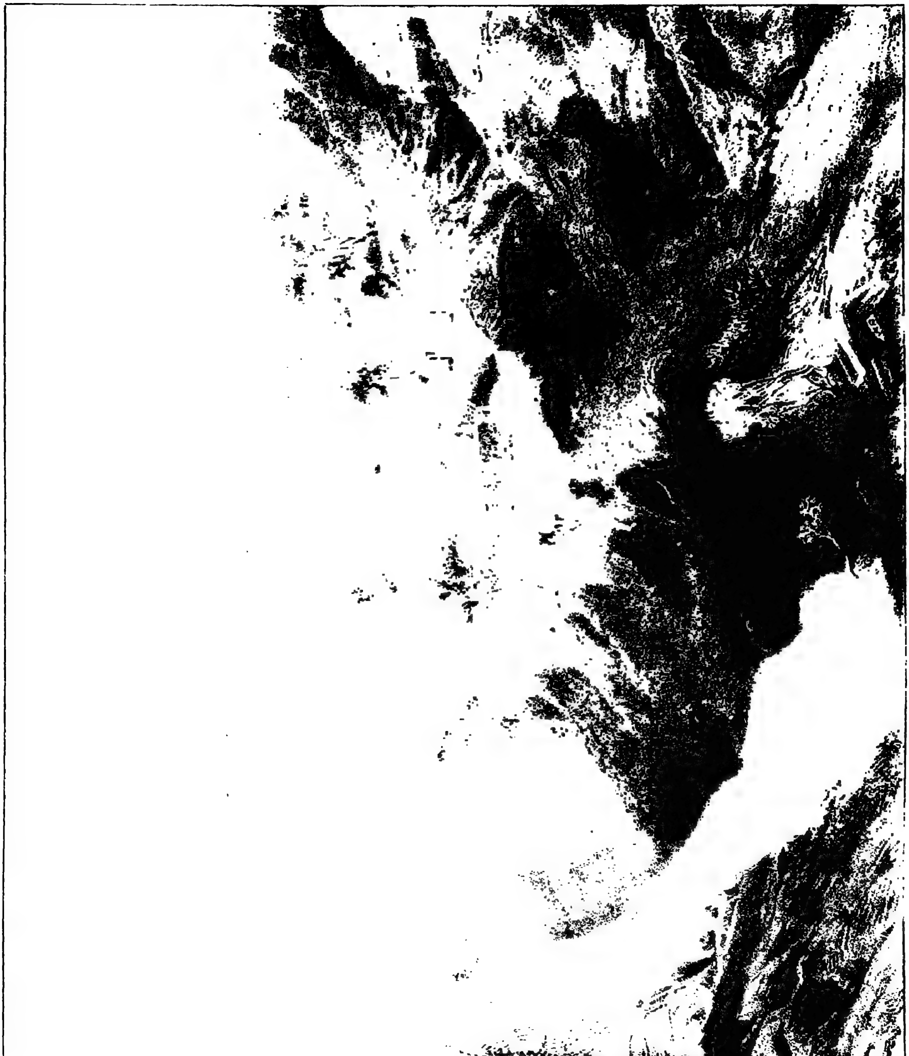
Upper Burma.—The earlier accounts appear to refer to only one neighbourhood, that of Yenan-gyoung, as yielding petroleum. Two groups of wells, at a distance of about two miles apart, are indeed spoken of; but it is only in more recent accounts that mention of a second locality, Pagan, is made. If it was then worked it does not appear to have been known even in the time of Colonel Phayre's mission to Ava, as Colonel Yule expressly mentions that the party could hear of no other wells than those described by himself and Dr. Oldham. He alludes, however, to a statement by Mr. Crawford that the wells extended over an area of 16 miles.

The name Yenan-gyoung is written as it is spelt by Colonel Yule, but there is little uniformity in the orthography adopted by different authors. In Dr. Balfour's Cyclopædia, under the head of Petroleum, descriptions are quoted of the wells at Ranangoong, Rai-nan-ghong, Yenan-gyoung and Yuynan-young, and no reader, in so far as the context is concerned, would conclude otherwise than that these were four distinct localities. They are, however, all one and the same. As already stated, *Yenan* is Burmese for petroleum.

YENAN-GYOUNG, Lat. 20° 18′; Long. 95°—The following account is chiefly compiled from Dr. Oldham's report, printed in Colonel Yule's 'Mission to Ava' in 1855,[2] and Colonel Yule's own remarks on the

[1] Or Banbyin or Pan-pyeng of map, &c., &c.

[2] London: Smith and Elder, 1858, pp. 18 and 316.



subject in the same volume. The wells are situated on a plateau surrounded by ravines at a distance of about 3½ miles from the town of Yenan-gyoung. They are said by Dr. Oldham to be distributed in two principal groups at two miles distance from one another. Colonel Yule states that each of these occupies an area of about half a square mile. He alludes to Mr. Crawford's statement that they cover an area of 16 square miles as being unintelligible, since repeated enquiry failed to elicit information as to the existence of others. It is considered that the oil is derived from a stratum containing lignite with a large proportion of sulphur; in one of the ravines an outcrop of a bed of this character was seen from which oil was oozing. No absolute section of any of the wells could be obtained, as owing to the loose and friable character of the ground the wells were timbered from top to bottom. According to the natives, after passing through the sandstones and shales which are visible at the surface they sink through a black rock about 10 feet thick, under which is a yellow bed from which the petroleum issues, and the colour of which is probably due to sulphur. It is believed that these rocks belong to the tertiary formation, and it is probable that they are of nummulitic age. The wells are about 4 feet 6 inches square and descend vertically from the top of the plateau to depths of from 250 to 330 feet, and on the slope from 110 to 180 feet, which would make them from 100 to 200 feet below the level of the watercourse at its base. Over each well there is a rude cross-bar and drum by which an earthen *ghara* is lowered and drawn up again by a man who walks down an inclined plane with the rope to which it is attached. The oil thus raised is poured into another *ghara* containing about 10 viss (= 36½ lbs.); 10 or 12 of these *gharas* make up a cart-load. The oil is raised only in the morning, and the quantity which each well is known by experience to yield, on the average, having been raised, work ceases and the well is allowed to rest and the oil to accummulate for 24 hours. The petroleum when first extracted has in mass a peculiar yellowish-green colour, is watery in appearance rather than oily, and has the consistency of cream. Some of the wells yield 400 viss; others only 60 or less. The headman of the village said there were 200 wells; others only 100. The estimated average yield was 180 viss. Taking these figures (200 × 180) and counting for 300 working days, the total produce would be 10,800,000 viss. Deducting one-twentieth for breakage, loss, &c., the net available produce is placed at 10,260,000 viss; but by another method, founded on the number of cart-loads carried from the wells, 4,500,000 viss is the sum arrived at. Colonel Yule states, from information received by the Envoy, that there were 80 wells in the northern group, with a daily average of 220 viss, which would be equal to an

annual production of 6,424,000 viss. The 50 wells of the southern group yield on the average 40 viss daily, which would be equal to 730,000 viss annually, making in all 7,154,000. This was about the amount stated by the Myok, who was a man of intelligence and had from his position the means of knowing.

The cost of digging a well 150 cubits deep (say 230 feet) is 1,500 to 2,000 tickals (or say Rs. 1,875 to Rs. 2,500). The work is one of considerable danger, and the miners are often rendered senseless by the exhalations, although when in the petroleum-yielding stratum they only remain down for a few seconds. If a man's tongue hangs out when he is drawn to the surface his case is hopeless, otherwise by shampooing he is brought round.

It is no doubt as the result of experience that the Burmese do not allow a well to be made within a distance of 30 cubits (say 50 feet) from one already existing. From this it may be concluded that the wells are capable of drawing from the surrounding strata through an area from the centre of the well, which has a radius of about 25 feet. Mr. Lyman, acting on American experience, recommended, in the case of the Punjab wells, that a distance of at least 50 feet should intervene between wells.

In a report by Captain Strover, published in the "Gazette of India," we have perhaps the most recent authentic account of the condition of the industry.

In 1873 there were 150 wells at Yenan-gyoung, which yielded 15,000 viss daily, of which 10,000 are taken by the contractor for British Burma and 5,000 by the contractor for Upper Burma. The total annual yield is 6,000,000 viss or 9,375 tons. There are many abandoned wells and wells that yield very small quantities.

There are also 50 wells at Pagan, which yield 1,500 viss. The oil there is in a more liquid state and more suited for burning than that at Yenan-gyoung. The total annual outturn in Upper Burma was, therefore, in 1873, 6,600,000 viss, or 10,312½ tons.

In a paper by Dr. H. Friedlander on 'The country of the earth-oil in Upper Burma,' which was printed in Rangoon in 1874, the figures given, so far as they go, are somewhat different. At Pagan there are, according to him, 70 wells, mostly new and with depths of from 60 to 80 feet. The average temperature of the oil was 27° C (=80·6 F.) and the sp.g. 0·810. It was much mixed with water and smelt strongly of naphtha. At Yenan-gyoung the number of wells is said to be 450, and the depth averages from 180 to 210 feet. The average temperature of the oil was 30° C (=86° F.) and the sp.g. was 0·862. The difference in the depths of the wells is attributed partly to the fact that those at Pagan

are in a ravine, while the others are on a plateau; and partly also to the fact that Pagan is on the margin of the basin, while the others are nearer the centre.

Dr. Friedlander mentions that an oleiduct was then in course of construction at Yenan-gyoung; it is constructed of bamboos with the inside lacquered, which are supported on stages and run from the wells to the river bank, a great loss of oil by evaporation being inevitable; but the system is a great improvement on the old one of carrying the oil in earthen *gharas* on a cart.

It may be of use to place here side by side the most important estimates as to yield, at the same time pointing out that some of the earlier ones are certain to be exaggerations, there being reason for believing that with the increased demand the yield also has increased. At the same time the largest estimate, that by Captain Cox, was arrived at, apparently, with considerable care. He states that there were 520 wells registered by Government; that he was told the average daily yield was 500 viss; but deducting for holidays, &c., he comes to the conclusion that 300 viss was a fair daily average. Probably the Government register included a large proportion of exhausted wells.

Estimates of the yield from the Petroleum Wells of Upper Burma.

Years.	Name.	Number of wells.	Average daily yield in viss per well.	Total annual yield. Viss.	Total annual yield. Tons.	Value.	References.
						Rs.	
1795	Colonel Symes .	500	...	...	90,900	...	'Embassy to Ava.'
1797	Captain Cox .	520	300	56,940,000	92,781¼	1,362,325 (Sicca)	Asiatic Researches, Vol. VI, p. 135.
1826	Mr. Crawford .	200	235	17,568,000	...	...	Journal of Embassy.
1835	Captain Hannay .	...	...	...	93,000	£90,000	MS.: part of this journal only published.
1838	Captain McLeod .	160	36	1,405,440	...	...	MS. in Foreign Office quoted by Colonel Yule.
	Dr. Oldham . .	200	180	10,800,000	...	...	Colonel Phayre's Mission to Ava.
1855	The same by a different estimate.	...	...	4,500,000	...	...	
	Colonel Yule .	80	220	7,155,000	11,690	...	
		50	40				
1873	Major Strover .	150[1]	100	6,000,000	10,132¼	...	Memorandum published in Rangoon.
		50[2]	30	6,00,000			

[1] Yenan-gyoung.
[2] Pagan.

The trade in this oilis at present in the hands of Moolla Ibrahim, a native of India. Owing to complications in the political relations which arose in the year 1879, all his stock, or the greater part of it, was sent into British territory. It has recently been stated in the newspapers that owing to competition caused by large importations of American kerosene, &c., into Burma, this man has applied for and been granted by the King a reduction of 50 per cent. in the royalty of Rs. 50,000, which he previously had to pay.

In the published returns of articles which crossed the frontier before 1878-79 the petroleum is not distinguished from vegetable oils. In nine months of 1855, 6,679,140 lbs. of oil paid duty at Thayetmyo, according to Colonel Yule. In 1878-79, 57,525 maunds of the value of Rs. 365,090, and in 1879-80, 108,519 maunds and 34 seers valued at Rs. 6,14,533 and 8 annas, were imported from Upper into British Burma. These figures do not represent the outturn, as a large quantity of oil is consumed in the country and exported eastwards. According to Major Strover, the contractor for British Burma at Yenan-gyoung gets 10,000 out of the daily yield of 15,000 viss, and the contractor for Native Burma the remaining 5,000. This does not refer to the outturn at Pagan, where the daily yield is about 1,500 viss. The chemical composition and properties of the so-called Rangoon oil, which though coming from Upper Burma acquires the name of the port from which it is shipped, has attracted the notice of several chemists in Europe and America, and before closing this account it will be well to give here a *résumé* from the published accounts of their researches.

In order of priority the first paper is by Dr. Christison of Edinburgh, which is dated 1831.[1] He found it impossible to analyse it by means of ordinary chemical re-agents, and so had recourse to distillation; the first product, when six ounces of petroleum were gently heated, was one ounce of straw-coloured naphtha, afterwards other products went over, and finally a substance resembling lard with a crystalline structure was obtained, for which the name petroline was proposed. Already, however, in 1830, Dr. Reichenbach had isolated a substance from tar, to which he gave the name paraffine. It was not long, however, before the properties of these substances were found to be so nearly identical that the name paraffine was universally adopted.

In the year 1834 Dr. Gregory[2] read a paper detailing the results of his analyses of Rangoon oils, which he summarised as follows:—

[1] Royal Society's Transactions, Edinb., Vol. XIII, 1834, p. 118.

[2] *Op. cit.*, p. 124, abstracted in Jour., As. Soc., Bengal, Vol. IV, p. 528.

1st.—There are some kinds of naphtha which contain paraffine and eupione, and are consequently the result of destructive distillation.

2nd.—The naphtha examined by Dr. Reichenbach, which was oil of turpentine, if genuine, differs materially from that of Rangoon and of Persia, as well as that sold now in Paris, which are decidedly not oil of turpentine.

3rd.—The fact of the oil of turpentine having been obtained by distilling brown coal at 212° proves that it had not previously been exposed to a heat sufficient to expel its oil of turpentine, and *à fortiori* that it had never been subjected to destructive distillation.

It would appear that Dr. Gregory did not realise what is now known to be the case that a slow natural distillation, if extended over long periods of time, is capable of producing results similar to those from quick artificial distillation. He pointed out how invaluable the eupione and paraffine would prove for lighting purposes if they could be economically extracted locally in Burma from the petroleum.

In the year 1856 Messrs. Warren De la Rue, Ph.D. F.R.S., and Hugo Muller, Ph. D., made an important contribution to the literature of this subject.[1] Although several tons of petroleum were obtained for the purpose of the investigation, it was found that even this large quantity was insufficient for the complete examination of several constituents, which were proved to exist in minute quantities; some of these were organic bases. It was found that 96 per cent. of the constituents, fluid and solid, are volatile. The latter or paraffine amounts to from 10 to 11 per cent., but it was found to retain a portion of the fluid hydrocarbons with much obstinacy. This paraffine was found to be separable into two portions with different properties but apparently the same composition.

By means of fractional distillations separation of the liquid constituents was effected, but no absolutely constant boiling points could be obtained. It was ascertained that the naphtha contained the following hydrocarbons : Benzol, $C_{12} H_6$; Toluol, $C_{148} H_8$; Xyol, $C_{16} H_{10}$; Cumol, $C_{18} H_{12}$. It would be scarcely appropriate in this volume to give further details of these researches ; it will be sufficient perhaps to indicate briefly the results of the latest enquiries of this nature. These are by Messrs. C. M. Warren and F. H. Strover ; the paper is dated 1865.[2] The results were obtained by the application of a new process of separating the volatile hydrocarbons by fractional condensation. Seven isolated pure substances were obtained between temperatures of 170° and 250°; but below 175°

[1] Procdgs., Royal Society, Vol. VIII, 1856, p. 221.

[2] Memoirs of the American Academy, New Series, Vol. IX, p. 208.

the quantities of liquid had become so small that no definite results could be obtained.

The final result was that Burma naphtha contains—

Rutylene	$= C_{20}\ H_{20}$	boiling point at	175°
Margarylene	$= C_{22}\ H_{22}$	" " "	195°
Laurylene	$= C_{24}\ H_{24}$	" " "	215°
Cocmylene	$= C_{26}\ H_{24}$	" " "	235°
Naphthalin	$= C_{20}\ H_{8}$		

also, probably, Pelargone $= C_{18}\ H_{18}$, boiling at about 155°, and indications of others.

The importance of such researches cannot be overrated even from the economic point of view, as they tend directly towards discoveries of possibly enormous value commercially.

In the year 1866 Dr. Waldie[1] reported on specimens of candles and earrings from Burma which proved to be made of paraffine. He notices that these petroleums resemble the products obtained from coal and bituminous shales by slow distillation as contrasted with the tar and gas which result from quick distillation.

The extraction of paraffine by artificial means involves somewhat complicated chemical and mechanical manipulation; but it would seem that naturally, under the influence of heat, atmospheric action and water, together with, probably, the agency of some of the constituents of the soil, the same substance is produced. Specimens of this natural paraffine which had been found on the surface in Burma had been examined by Dr. Waldie, proving how really potent feeble chemical agencies are if only extended over long periods of time. It is possible that to some such action still further extended the diamond owes its origin.

[1] Jour., As. Soc., Bengal., 1866, pp. 18, 73.

CHAPTER III.

SULPHUR—MOLYBDENUM—ARSENIC—BISMUTH—ANTIMONY—PLATINUM—MERCURY.

SULPHUR—General remarks—Madras—Bombay—Balochistan—Afghanistan — Punjab—Kashmir—North-West Provinces—Nepal—Upper Burma—Barren Island. MOLYBDENUM—General remarks. ARSENIC—General remarks—North-West Provinces—Upper Burma. BISMUTH—General remarks—Bengal—Punjab—Nepal—Burma. ANTIMONY—General remarks—Madras—Hyderabad—Bengal—Rajputana—Balochistan—Afghanistan—Kashmir—Punjab—Burma. PLATINUM—General remarks—Madras—Bombay—Punjab—Assam—Burma. MERCURY—General remarks—Madras—Afghanistan—Andaman Islands—Aden.

Sulphur.—General Remarks.—In India, as in other parts of the world, the principal natural sources of sulphur are, firstly, deposits formed in connection with hot springs; and, secondly, deposits which owe their origin to active or extinct volcanoes.

As a general rule the deposits formed by hot springs, active or extinct, which contain sulphur, consist principally of gypsum. In the former case, since the reaction by which the sulphur is released is in progress a continuous, though possibly small, addition to the deposit is going on, and thus sufficient for a limited local consumption may annually be produced. Where, however, the thermal spring has become extinct, the deposit has reached its maximum, and in most cases on being worked speedily becomes exhausted. The same remarks apply too, but on a generally larger scale, to the deposits formed by active or extinct volcanoes respectively.

Sulphur, whether its origin be connected with thermal springs or volcanoes, may occur either in the massive or crystalline côndition. In the latter case the crystals are acute octohedrons or secondaries to that form and belong to the trimetric system.

In combination with several metals sulphur forms sulphides or sulphurets, the principal of the ores so formed being pyrite (iron sulphide); pyrrhotite (magnetic iron sulphide); galena (lead sulphide); chalcopyrite (iron and copper sulphide); cinnabar (mercury sulphide); argentite (silver sulphide); stibnite (antimony sulphide).

On a small scale, under the influence of the atmosphere alone, and not necessarily accompanied by or giving rise to hot springs, the decomposition of these sulphides sometimes forms deposits of sulphur of greater or less extent. In the case of hot springs the production of

sulphur is perhaps generally due to reaction between iron sulphide and carbonate of lime, the resulting products being sulphur, gypsum, and iron oxide.

By artificial treatment of these ores, especially pyrite and chalcopyrite, a considerable proportion of the sulphur and all or nearly all the sulphuric acid of commerce are prepared.

The known sulphur deposits of India are not of great importance, as the most considerable are situated in remote localities which are difficult of access. Nearly the whole supply of British India, therefore, is imported from foreign countries. The details of the trade are given in Appendix A.

Madras: Godavari District.—SURA-SANY-YANAM (*Sooree Saneeanum* of map.), Lat. 16° 29′; Long. 82° 9′ 30″.—In the vicinity of a village of the above name, which is situated between two of the mouths of the Godavari, not far from the sea-coast, Dr. Heyne[1] examined a curious deposit of sulphur, the result apparently of the decomposition of sulphate of lime or gypsum, of which traces were found to exist in the water; but he failed to detect any exhalation of sulphuretted hydrogen gas. The precise locality was a tidal swamp in the dried-up margin of which the sulphur was collected where it occurred in small heaps. No information exists as to whether the sulphur was ever collected in sufficient abundance to be of commercial importance, and it is probable, therefore, that it was not.

A deposit of crystalline sulphur, recently discovered under Paris,[2] owes its origin to a similar cause, namely, the deoxidisation of the gypsum, which occurs in the soil there, by contact with organic refuse.

Bombay.—GHIZRI BANDAR, Lat. 24° 48′; Long. 67° 8′.—On the Ghizri creek, near Karachi, a deposit of sulphur was discovered in the year 1843 by Captain Preedy,[3] the Magistrate and Collector. Although the available amount of sulphur was estimated to be large, a sample which was forwarded to the Asiatic Society only weighed 20 grains. In connection with the sulphur a considerable amount of saltpetre was stated to be present.

Mr. Piddington's assay of the sample proved that it consisted of 60 per cent. of sulphur. Whether his very full instructions as to the manner in which the value of the deposit should be tested were carried out does not appear. As nothing more has been heard of this deposit it was probably of trifling extent.

[1] Tracts, London, 1814, p. 187.
[2] Nature, 1881, Vol. 23, p. 397.
[3] Jour., As. Soc., Bengal, Vol. XII, p. 833.

Balochistan.—SUNNEE (BAGH).—At Sunnee, a distance of 40 miles from Bagh, in Cutchi, there is a considerable sulphur mine. From a description by Captain Hutton,[1] the mining appears to have been carried on on a large scale; but in 1839 the lessees paid only Rs. 700 for the right to mine.

There are said to be several extensive chambers within this mine, to which access is obtained by adits. Into one of these chambers petroleum slowly drips and is collected in a well; it is employed to mix with the refuse of the sulphur workings by which an inferior quality of material is made. The pure sulphur is boiled in oil in order to prepare it in the form of commercial brimstone.

Kandahar used to be, if it is not still, chiefly supplied from these mines; but other mines in Gurmsael and Balkh contributed to the amount annually consumed. The price ranged according to season from about 2½ to 8 annas per seer.

Captain Hutton mentions Seeree, in the Mari country, as being reported to be another source, but he did not know the particulars. Possibly it may be identical with the next-mentioned locality, though it is not in the Mari country.

Afghanistan: SOREE PASS, Lat. 30° 12′ 30″; Long. 70° 20′.—In the Suleiman hills to the west of Dera Ghazi Khan sulphur is manufactured by the natives in some abundance. The exact locality is near a hot spring called Pir Zinda in the Soree Pass.

Specimens of the crude ore and manufactured sulphur were brought to Dera Ghazi Khan.[2] The former consisted of amorphous gypsum with strings and veins of sulphur running through it. The tribes called Kusranis and Bozdars manufacture the sulphur from this by means of a simple retort formed of two *gharas*, one being placed on a fire and the other inverted upon it mouth to mouth so as to catch the fumes. The occurrence of this sulphur is evidently connected with the presence of the above-mentioned hot spring.

HAZARA.—Captain Drummond, in his account of the mineral resources of Northern Afghanistan,[3] mentions the bare fact that sulphur is obtained in Hazara, where it is said to occur in vast quantity.

Punjab: Kohat District.—GUNJULLY HILLS, Lat. 39° 25′ 30″; Long. 71° 48.′—Certain pyritiferous alum shales, of probably nummulitic age, form the southern flanks of the above-named hills in the Kohat district. They are described by Mr. Wynne,[4] who states that

[1] Cal. Jour., Nat. Histy., Vol. VI, 1846, p. 564.
[2] Records, G. S. I., Vol. VII, p. 158.
[3] Jour., As. Soc., Bengal, Vol. X, 1841, pp. 92, 93.
[4] Mem., G. S. I., Vol. XI, pp. 204, 293.

they were burrowed into formerly in the search for sulphur, of which it is reported that 1,000 tons used to be annually manufactured.

Although on the particular spot where the pits are situated the best part of the deposit may have been exhausted, it is considered by the same authority that there is no reason for doubting its extension beneath the neighbouring debris.

The deposition of sulphur is evidently still in progress, as the whole place emits sulphurous fumes and native sulphur occurs on the sides of small cracks in the shales.

Mr. Wynne expresses astonishment at these deposits not being worked at present for the gunpowder factory at Lachi.

Luni-ki-Kussi, Lat. 33° 36′ 30″; Long. 72° 2′ 30.″—The sulphur pits at this locality are described by Mr. B. S. Lyman,[1] who states that they are on the west side of the Indus, about two miles north-east of Churlu-ki-Mishuk and a mile south-west of Dundi.

Sulphur used to be obtained by roasting the loose earth. The tradition of the neighbourhood points to there having been a large supply, though none is actually exposed on the surface. Asphalt, gypsum, and salt are all found in small quantities close by.

Nakband or Kushalgarh, Lat. 33° 28′ 30″; Long. 71° 57′ 30″.—This locality, situated on the Indus between Attock and Kalabagh, and 8 miles from the mouth of the Kohat river, is described[2] as yielding sulphur in considerable quantity, works having been set up there by the Maharaja of Kashmir.

In three years 1,000 Lahori maunds of sulphur are said to have been extracted here for the manufacture of gunpowder for the Sikh army and sold at the rate of Rs. 6 a maund. The mines are reported to be from 30 to 40 feet deep. The process of extraction by sublimation which is practised here is similar to that already described.

Sulphur is also said to occur at Gumbat and near Panoba, 4 miles from Shadepur on the Indus, both also in the district of Kohat.[3]

Bannu District: Jaba, Lat. 32° 52′; Long. 71° 45′.—Sulphur associated with petroleum occurs, according to Dr. Flemming,[4] in no great abundance south of the Indus, about 14 miles from Kalabagh. This appears to be identical with Jaba mentioned by Mr. Baden-Powell[5] as

[1] Report on Oil Lands, Lahore, 1870, Supplement, p. 1.

[2] Punjab Products, Vol. I, p. 20.

[3] *Vide* Wood's Journey to the Oxus, p. 144. B. S. Lyman. Report on Oil Lands: Lahore, 1870, Supplement, p. lii.

[4] Jour., As. Soc., Bengal, Vol. XVII, Part II, p. 517.

[5] Punjab Products, Vol. I, p. 20.

a locality yielding a trifling amount of sulphur and not the Jaba in Shahpur. The Maharaja Gulab Singh closed the works there as they proved to be unprofitable.

Mr. Wynne[1] considers that none of the sulphur deposits of the Salt-range, east of the Indus, are of any substantial economic value.

Simla District.—A cake of sulphur from Jeura, near Simla, was exhibited at the Punjab Exhibition,[2] but the available amount does not appear to be of importance.

Kashmir: PUGA, Lat. 33° 17′ 30″; Long. 78° 25′.—The sulphur mines at this locality, which is a valley in Rupshu, situated between Lake Chomoriri and the Indus, at an elevation of about 14,500 feet, have been visited and described by General Cunningham and Mr. Mallet.[3]

The matrix is a much cleft and contorted quartz schist, and the sulphur is found both between the laminæ and in the clefts and fissures; sometimes it is massive, but oftener it lines the walls of the clefts with small transparent crystals; crystals also occur in the massive gypsum which is found in the fissures.

The mines are vertical holes about 8 feet deep, from the bottom of which the rock is excavated laterally for about the same length, and are afterwards deserted for new sites. Close by there are hot springs, which still deposit sulphur, and there can be little doubt that both the gypsum and sulphur in the mines were produced in the same manner. Even at present the mines are very hot, indicating that chemical reactions are in progress at no great distance. The mines belong to the Maharaja of Kashmir. The outturn is said to be from 500 to 600 maunds. The process of manufacture is rude and wasteful in the extreme.

General Cunningham states that in 1847 the Puga mines were somewhat neglected owing to sulphur being more easily obtainable at Changthang. The annual outturn he estimated at not more than 50 maunds at 16 seers each or a sheep's load.

North-West Provinces: Kumaun District.—In the beds of the Ramgunga and Garjia rivers sulphur is found in the deposits from hot springs according to Captain Herbert.[4] It is said to be there associated with carbonate of lime, from which it can be readily sublimed. Such an association, though not common, is occasionally found to exist, but it may be perhaps that in this case the substance was really the sulphate of lime or gypsum.

[1] Mem., G. S. I., Vol. XIV, p. 283.

[2] Punjab Products, Vol. I, p. 19.

[3] Mem., G. S. I., Vol. V, p. 162. These mines are also described in Punjab Products, Vol. I, p. 19.

[4] As. Res., Vol. XVIII, p. 229.

It is also found at Munsiari in Northern Kumaun, according to Mr. Lawder,[1] but its abundance there has not been ascertained. Apparently unimportant deposits occur also in Garhwal.

Jaunsar District.—In the galleries in the lead mines at Meywar, on the Tons river, sulphur occurs in considerable quantities according to Captain Herbert.[2]

Nepal.—Sulphur mines are known to exist in Nepal but particulars, regarding them are not available. In the year 1857 Mr. Hodgson[3] reported that owing to want of skill the mines there were not worked with profit.

The imports of sulphur from India at that time were to the value of Rs. 6,000 per annum, which at the then prime cost of Rs. 13 a maund represented a weight of about 16½ tons.

Upper Burma.—Sulphur not being mentioned in the "British Burma Gazetteer" among the Economic Products of value, it must be concluded that it does not occur there in sufficient abundance to be manufactured with profit; but in Upper Burma, according to Major Strover,[4] a considerable quantity is manufactured by the King. The supply of ore in the Shan States is stated to be unlimited, but its exact nature is not quite clear, as, although it is called a hard metallic pyrites, it is distinctly stated not to be iron pyrites. It occurs in tertiary blue clays 12 to 20 feet below the surface. Dr. Oldham, when at Amarapura, was shown some iron pyrites from the Shan States which was said to have been used as an ore of sulphur.[5] The process of extraction is essentially identical with that practised in Balochistan, &c., common earthen vessels being used as substitutes for retorts.

The following is a list of the principal localities where there are factories, with the average outturns :—

Mooda Myo N.	3,000	Viss.
Tsein Goon E. S. E.	2,000	"
Kyoukhoo S. E.	3,000	"
Bawyine, Shan States S. E.	6,000	"
Dybayen Myo N. W.	4,000	"
Pagan Myo, west bank of Irawadi	4,000	"
Toogthoo Einlay E. S. E.	4,000	"
Bhamo District	2,000	"
Total	28,000	"

[1] Records, G. S. I., Vol. II, p. 88.

[2] As. Res., Vol. XVIII, p. 229.

[3] Selctions from Records, Bengal Government, No. XXVII, p. 35.

[4] "Gazette of India," reprinted in the "Indian Economist," Vol. V, 1873, p. 14.

[5] Colonel Yule's Mission to Ava, p. 347.

The annual imports from Yunan are considerable and European sulphur is obtainable in the bazars at the rate of Rs. 3 per viss.

Barren Island, Lat. 12° 17′ N.; Long. 93° 54′ E.—Barren Island is a volcano which, so far as is certainly known, has not been in a state of violent eruption since the years about the close of the last and commencement of the present centuries. Since then it has been visited at long intervals and the accounts, with one exception,[1] represent it as merely pouring forth a greater or less volume of white smoke from the summit.

The fissures from which this smoke issues are lined with crystals of pure sulphur, and scattered crystals occur with selenite throughout the cap of ashes at the summit.

The possibility of this island yielding sulphur in sufficient abundance to support an establishment in connection with the convict settlement at Port Blair has been discussed both by Dr. A. von Liebeg[2] and the present writer.[3]

At present deposition takes place only at the summit, and certainly not with sufficient rapidity to make it pay to keep an establishment on the spot. It is possible that in parts of the cone there may be old deposits, but they are not likely to be of large extent, and on being exhausted they would not be again replenished.

Had the island any inhabitants who could find other regular means of subsistence, some profit might be derived from thec ollection of this sulphur; but as it has not, there can scarcely be said to be any prospect of Barren Island sulphur becoming an article of commerce.

Molybdenum—General Remarks.—This metal occurs generally as the sulphide or molybdenite, and has never been found native; an oxide resulting from the alteration of the sulphide is occasionally found. In combination with lead it forms the molybdate of lead, which is the only native salt containing it.

Molybdenite has occasionally been found in small quantities in the crystalline or metamorphic rocks of India, especially in those of Chutia Nagpur. Its appearance is so like graphite that it is often mistaken for it. Recently samples of it have been brought to the Museum from galena mines in Hazaribagh.

The only use to which molybdenite is put in the arts is in the preparation of a blue pigment for pottery-ware. The metal is not employed for industrial purposes at present.

[1] A number of the "Bombay Times" for July 1852 is stated to contain an account of it as being then in a very active condition.

[2] Jour., As. Soc., Bengal, Vol. XXIX, p. 8.

[3] Records, G. S. I., Vol. VI, 1873, p. 31; and Geol. Mag., Dec., II, Vol. VI, No. I, p. 10.

Arsenic—General Remarks.—This metal occurs native and in combination with other metals in various ores. It also occurs in the form of sulphides as orpimentand realgar, and sparingly as an oxide. The last is of the same composition as the common white arsenic which is an artificial preparation. Within British territory but one locality is known, and that vaguely, where an ore of arsenic occurs in sufficient quantity to be worked. Elsewhere traces of it have been found in combination with ores of antimony, lead, copper, and iron, but in too small quantities to be of economic importance.

During the past four years the average imports of arsenic of all kinds into British India by sea amounted to 52 tons, but in the last of these only 15 tons are returned. The United Kingdom, Austria, China, and Turkey in Asia, besides other countries, contribute to this supply.

White arsenic, orpiment, and realgar are to be obtained in every native bazaar. They are used in Materia Medica, as pigments, in the manufacture of paper which is indestructible by insects, for poisoning wild animals, and not unfrequently in the perpetration of murder; but for this last purpose, being comparatively easy of detection, they are not so well suited as some other substances, as has recently been minutely explained in an official document published for general instruction.

North-West Provinces: MUNSIARI.—Arsenic in the form of orpiment or yellow sulphide is said[1] to occur in the northern part of Kumaun at the above-named locality. Small quantities are brought for sale by the Bhutias to the Bagesar fair.

Yellow orpiment reaches India overland from Swat and Kashgar, and is to be had from those localities in the Peshawar bazaar. That which is sold in Kandahar[3] or a portion of it comes from Herat.

According to Mr. Hodgson[4] Nepal does not produce any, but imports its supply from India. In 1857 the different varieties imported had a total value of 1,400 Rs. at Rs. 4 a seer, or, in other words, 700 lbs. weight represented the then average amount of consumption in Nepal.

Burma.—Red and yellow orpiment from Upper Burma is said to be commonly sold in British Burma bazaars. An ore of arsenic was reported by Dr. Helfer to exist on one of the islands of the Mergui Archipelago, and other arsenical ores have also been discriminated in different parts of Burma.

[1] A. Lawder. Records, G. S., I., Vol. II, p. 88.
[2] Punjab Products, Vol. I, p. 66.
[3] Cal. Jour., Nat. Hist., Vol. VI, p. 604.
[4] Selections from Records, Bengal Government, No. XXVII, p. 34.

Bismuth—General Remarks.—This metal occurs both native and in combination with other metals, &c. It has many uses in the arts; alloyed with tin and lead it forms soft solder, and is used to take *clichés* for stereotypes. With tin and lead in the proportion of 8 bismuth, 5 lead, and 3 tin it forms 'fusible metal' which melts at a temperature of 200° F. It also enters into the composition of various medicines, mordants for calico printing, and pigments for colouring glass and porcelain.

So far as is known, bismuth does not occur in quantity in any part of India, but in different localities traces of it have been ascertained to exist in the ores of other metals as follows.

Bengal: Singbhum District.—Traces of bismuth were met with in the copper ores of Singhbhum.[1]

Punjab: Mundi State.—At Thirri, in the estate of the Raja of Mundi, on the borders of Kulu, there is, according to Mr. Calvert, a lode of manganese and bismuth ore of small size in a matrix of pink limestone. Mr. Baden-Powell states that small quantities of bismuth have been obtained from Jammu territory, in Kashmir.

Nepal.—In the account of the copper of Nepal in Chapter V the analysis of a mineral by Mr. Piddington for which he proposed the name Nepaulite will be found. It will be seen that this mineral, if the analysis be correct, includes a very large percentage of carbonate of bismuth, 34·8, and it might appropriately be called an ore of bismuth, as it therefore contains 24·6 per cent. of that metal, while of metallic copper the percentage is only 14·4.

Burma.—Traces of bismuth have been found in ores of antimony and galena from Burma.

Antimony—General Remarks.—Owing to the common custom of applying the Hindustani term *surma*, which strictly speaking means antimony, to galena, and further, owing to the custom of using powdered galena for anointing the eyes, antimony being the substance which is properly applicable to that purpose, it is not always easy to determine whether writers are referring really to antimony or to lead ore. In some cases internal evidence shows that the term 'antimony' is not applicable to the mineral described as *surma;* but in others a doubt cannot fail to be felt as to whether the writer is speaking with authority or not. As a matter of fact, stibnite or antimony sulphide very commonly occurs in association with lead sulphide or galena. In the majority of these cases, however, there are only traces present, and as such they have no real economic importance.

[1] Records, G. S. I., Vol. III, p. 97.

Madras: **Bellary District.**—Antimony, together with lead, manganese, and iron, is said[1] to occur in the Sandur hills, but no particulars as to its abundance are available.

Mysore.—Dr. Clarke[2] states that antimony was brought to him by a native from Baba Boodens, where it was said to be abundant.

Vizagapatam: KODUR.—At Kodur, 2 miles from Chipurapilly, antimony is found and is sold for two annas a pound. Some of it, which was exhibited at the Madras Exhibition of 1857, was reported to have been of good quality.[3]

Hyderabad: YENCHAPALI.—At Yenchapali or Enchinpilly, on the Nizam's side of the Godavari, several miles below the point where the Indravati joins it, Mr. Vanstavern has reported that stibnite was found in a well-sinking at a depth of 34 feet from the surface.

Bengal: **Hazaribagh District.**—HISATU.—In the account of the lead ore of this locality will be found an analysis of the galena, from which it appears that a sample yielded 17 per cent. of the antimony sulphide, the equivalent of which is 4·7 of metallic antimony. There was, therefore, more ground for describing this as an antimony mine than many other localities. Traces of antimony occur also with the galena of the locality near Dhadka, in Manbhum.[4]

Rajputana: **Ajmir.**—TARAGARH.—It is said that antimony occurs with the lead ores of this locality which are described in Chapter VI.

Balochistan: BEYLA.—Together with some lead ore, samples of antimony ore are said to have been forwarded from Beyla to the Bombay Geographical Society by Captain Boyd.

SEKRAN.—In the Sekran lead mines, which are also described in Chapter VI, antimony is reported to occur.

QUETTA.—A mass of *pure* (?) antimony was shown to Captain Drummond,[5] which was reported to have been obtained near Quetta; possibly it was obtained at the locality to be next mentioned.

Afghanistan: KILLA ABDULLA IN PISHIN.—Stibnite, according to Captain Hutton,[6] occurs abundantly in some of the mountains to the northward of Killa Abdulla. It is said to be accompanied by the white oxide or valentinite.

[1] Bellary District Manual, p. 95.
[2] Madras Jour. of Lit. and Sci.. Vol. IX (1839), p. 120.
[3] Vizagapatam District Manual, p. 155; and Balfour's Cyclopædia, Art.—Antimony.
[4] Records, G. S. I., Vol. III, p. 75.
[5] Jour., As. Soc., Bengal, Vol. X, p. 92.
[6] *Idem*, Vol. VI, p. 536.

FULIGIRD.—According to Dr. Lord[1] a mine of antimony exists on a limestone hill west of Fuligird in Ghoraband.

Antimony is said to reach India in some quantity from Kabul and Kandahar, but the exact sources are not known; probably the above localities include the principal. A portion, however, is said to come from Bokhara.

Kashmir.—It seems to be doubtful whether true antimony occurs in Kashmir, although a quality of *surma* superior to that of Shigri was said to come from Jamu.[2] Ore brought from Reyasi, in Jamu, proved to be galena.[3]

Punjab: Lahul District SHIGRI.—Mr. Calvert describes[4] his discovery of an enormous lode containing antimony ores in great abundance at Shigri. Subsequently, he tells us that Mr. A. G. Young found a second smaller lode higher up on the hill-face in the year 1872, which had, however, been known at an earlier period, as some mining operations had been carried on there by Major Hay 18 years previously.

The lower lode is stated to be 40 feet wide and to contain 20 feet of stibnite or antimony sulphide and the oxides, cervantite and kermesite, which result from its decomposition and form a sort of froth at the surface.

Mr. Calvert, after 18 months' delay, obtained from Government a lease on liberal terms, his intention being to form a company with the object of shipping the ore, reduced to a *regulus*, at an estimated cost of £32 per ton, the value in England being also estimated at £76 per ton.

Owing to the difficulties presented by the routes this deposit is very disadvantageously situated, and no permanent result seems to have followed from Mr. Calvert's projected scheme.

Mr. Mallet, who visited the locality eight or nine years before, describes[5] having found loose blocks of the ore close to the Bara Shigri glacier. These consisted of such pure ore that he was of opinion that if it were abundant it might profitably be carried three marches and across the Hamta Pass (14,500 feet) to the neighbourhood of the forests on the south side, where it might be reduced. From these forests to Sultanpur, the capital of Kulu, there are four marches.

An analysis of this stibnite by Mr. Tween indicated the presence of iron, alumina, lime and chlorine, with traces of copper and arsenic.

[1] Cal. Jour., Nat. Hist., Vol. VI, p. 599.
[2] Madras Jour. Lit. and Sci., Vol. XVII, p. 254.
[3] Punjab Products, p. 11.
[4] Kulu, p. 61.
[5] Mem., G. S. I., Vol. V, p. 165.

Associated with it in small quantity are zinc (*blende*), iron pyrites and manganiferous carbonate of iron. The rock in which these lodes occur is gneiss.

An earlier published account of this antimony is to be found in the "Madras Journal of Literature and Science."[1] M. Marcadieu, who visited the mines which were opened by Major Hay, while he acknowledged the richness of the deposits, expressed an opinion that, situated as they were at an elevation of 13,507 feet, no commercial benefit could be anticipated from working them. Six distinct lodes were said to be then visible, and a sample of ore yielded, according to Dr. Macnamara, 60 per cent. of pure metal. Major Hay suggested that, as the commercial value of antimony for the purposes for which it is ordinarily used had somewhat depreciated, it should be employed for cannon-balls, for which it was admirably suited; he stated that the mines might be worked on a scale sufficient to supply all the magazines in Northern India with shot. Major Hay was refunded the actual expenses incurred by him in his researches, but the Government refused to sanction his working the mines, as no material advantage was expected to be derived from the undertaking.

According to Mr. Baden-Powell[2] specimens of antimony from the following districts and localities in the Punjab were contributed to the Lahore Exhibition:—

Kangra District, Spiti.—The ore was associated with iron pyrites.

Hazara District, Bakot.—An unimportant deposit, erroneously supposed to be tin ore.

Peshawar District, Bajaur.—A good ore valued at Rs. 12 a maund.

Simla District, Sirmur.

Dera Ghazi Khan District, said to be from the lower hills. A rather doubtful locality considering the nature of the rocks.

Burma: Province of Tenasserim, Amherst District.—Antimony ore occurs associated with galena in various parts of Tenasserim. It was found by Mr. O'Riley[3] at the sources of the Ataran, and is said to be often met with on the mountains that bound the Thoungyeen. Captain Foley[4] mentions one locality under the name Guangdey (Gyaing).

Mr. Theobald mentions that no ores of antimony are worked at present in British Burma, but the metal is imported to a small extent

[1] Vol. XVII, p. 254.
[2] Punjab Products, p. 11.
[3] Mason's Burma, p. 49; and British Burma Gazetteer, Vol. I, p. 65.
[4] Jour., As. Soc., Bengal, Vol. V, p. 272.

from the Shan States. The principal well-known deposit in Tenasserim is situated near Maulmian.

MAULMAIN.—Large quantities of antimony ore are said to have been dug out here, but as there was no sale for it in Calcutta, operations ceased. A number of samples forwarded to the Asiatic Society, by Messrs. Fowle and Lonsdale, were reported on by Mr. Piddington. These samples were found to contain, in addition to antimony, iron, arsenic, bismuth and molybdenum.

Straits Settlements.—It may be of interest to add that a sample of native antimony was received by the Geological Survey[1] from the Home Department for examination. It was stated to have been found on Pulo Obin or Ubin, an island lying at the east end of Silat Tambran, the strait dividing Singapore from the mainland. It contained no trace of arsenic or silver, and only slight traces of iron and sulphur. Further research did not result in the discovery of any additional samples.

Borneo: Sarawak.—Recently Mr. Mallet[2] has met with both crystalline and massive senarmontite in a sample of antimony ore from Sarawak. This sample consists mainly of native antimony with stibnite, but valentinite, cervantite and senarmontite are also present. It is believed that this is the first record of the last-mentioned ore of antimony having been found in Borneo.

Platinum.—Platinum seldom, if ever, occurs pure in nature. It is usually combined with one or more of the rare metals, iridium, rhodium, palladium, or osmium, as is examplified by an analysis by Mr. Prinsep, which is quoted below; occasionally, too, either copper or iron or both are present in the combination.

Several of the reported instances of the occurrence of platinum in India are perhaps open to question. Thus Mr. Piddington doubtfully states that a trace of platinum occurred with some gold-dust obtained from Midnapur.[3]

Platinum is probably in all cases, where it has been found in India, originally derived from metamorphic rocks. It may be mentioned here that about 500 pounds weight of platinum is obtained annually in Borneo.[4]

Madras: MYSORE.—According to Mr. Rice[5] platinum in small quantities has been obtained at the gold-washings in the Kolar district.

[1] Records, G. S. I., Vol. IV, p. 48.
[2] *Idem*, Vol. XI, p. 260.
[3] Jour., As. Soc., Bengal, Vol. XXIV, p. 251.
[4] Dana. Manual of Mineralogy, 3rd Edition, 1879, p. 126.
[5] Mysore and Coorg Gazetteer, Vol. I, p. 18.

Bombay: DHARWAR DISTRICT.—In two of his papers Captain Newbold[1] refers to some particles of what he thought to be platinum as occurring with the gold-dust in the washings in the Kappatgode region. As elsewhere stated in these pages, native silver has been found there.

Punjab.—According to Mr. Baden-Powell,[2] in the streams of the Indus Valley in the Punjab, where gold is washed for, grains of platinum are occasionally found in small quantities; the gold-seekers call it *safed sona* (white gold) and reject it as useless. He adds that it has been found in the Tair river, in Jamu territory, and in the Kabul river at Naushera. Previously, Dr. Fleming,[3] in the account of his trip to Pind Dadun Khan, &c., as pointed out by Mr. Wynne,[4] stated that in spite of repeated enquiries from the gold-washers he failed to discover that platinum had ever been found. Mr. Wynne subsequently[5] further confirms this.

Assam.—Some gold sand obtained in the Noa Dihing river, in Upper Assam, by Colonels Dalton and Hannay was found by Dr. Oldham to contain platinum.[6]

British Burma: HENZAI.—Dr. Oldham[7] detected a minute particle of platinum with some washed gold and tinstone which were obtained by Mr. O'Reilly in the streams which fall into the Henzai basin, in the Tavoy district of the Tenasserim Division.

Upper Burma.—In the year 1831 Mr. Charles Lane forwarded to the Asiatic Society a button of white metal which had been obtained by melting up together some grains obtained in the gold-washings near Ava. Mr. J. Prinsep subjected this button to analysis and obtained the following result:—

Platinum	25
Gold	5
Iridium and Osmium	40
Iron	10
Arsenic and lead	20
Rhodium ?	
Palladium ?	
	100

[1] Jour., Roy. As. Soc., Vol. VII, p. 206; and Jour., As. Soc., Bengal, Vol. XIV, p. 291.
[2] Punjab Products, p. 14.
[3] Jour., As. Soc., Bengal, Vol. XVIII., p. 682.
[4] Mem., G. S. I., Vol. XIV, p. 27.
[5] *Idem*, Vol. XVII, p. 95.
[6] *Idem*, Vol. I., p. 91.
[7] Sel., Rec., Bengal Gov., No. VI, p. 38.

This appears to be the first recorded case of the occurrence of an alloy of platinum in Southern Asia.[1]

The examination of a further sample by Mr. Prinsep[2] led him afterwards to conclude that the ore contained only 20 per cent. of platinum and about twice that amount of iridium. The amount of osmium was not determined, but, besides the platinum and iridium, the bulk of the ore was chiefly oxide of iron. As remarked by Mr. Theobald[3] the proportion of iridium indicated by these assays is remarkable, and a further examination is much to be desired. It is stated that the Burmese are capable of manipulating the metal, which, if true, affords additional evidence of their well-known skill as metallurgists.

With reference to the mode of occurrence of this ore Major H. Burney[4] supplied Mr. Prinsep with the following particulars.

A good deal of it is brought from some streams which fall into the Kyendween river from the west near a town called Kannee. It is said to be collected in the following curious manner. The horns of a species of wild cow called Tsain (*Bos sondaicus*), which are covered with a velvet coat up to the age of two or three years, are placed in the streams, and at the close of the rainy season, when the water subsides, they, together with the sand surrounding them, are carefully raised with cloths wrapped round them. The horns, it is suggested, cause a concentration at these spots of the gold-dust which is brought down by the streams. With this gold-dust the grains of platinum ore are found, but it is the former alone which is regularly brought into Ava for disposal.

This use of the horns is also alluded to in another paper,[5] and it is said, on the authority of Mr. Lane, that they, with the gold-dust adhering to them, are sold for from 12 to 13 tickals (= £1-12-6 to £1-15) a piece. This seems so large a sum that it suggests that the story may have arisen from the gold-dust being stored in the horns when collected by other means. A good deal of this ore is said to occur in the same association with the gold-dust in the streams which fall into the Irawadi in the direction of Banman (Bhamo.) According to Major Strover[6] platinum is reported to occur also in the Shan States.

By the Burmese platinum is known as *shenthan* or *shwabeen*, which means white gold.

[1] Gleanings in Science, Vol. III, p. 39.
[2] As. Res., Vol. XVIII, p. 279.
[3] Records, G. S. I., Vol. VI, p. 95.
[4] Jour., As. Soc., Bengal, Vol. I, p. 16.
[5] *Op. cit.*, Vol. III, p. 207.
[6] Indian Economist, Vol. V, p. 14.

Mercury—General Remarks.—This metal occurs both native and in combination with other substances. Alloyed with silver it constitutes native amalgam. Its most abundant ore is the sulphide or cinnabar, which when in a pure state is the pigment vermilion. From this ore the mercury of commerce is chiefly obtained, as the uncombined metal seldom occurs in any great abundance. The mode of occurrence is somewhat variable: at Almaden, in Spain, it impregnates vertical strata of quartzose sandstone which are associated with carbonaceous slates; in the Asturias it occurs in carboniferous strata; in San Francisco it occurs in altered cretaceous strata with which serpentine is associated; sometimes the cinnabar is found actually in the serpentine. This point is of particular interest in connection with India, since, in the Andaman Islands, where, according to an old rumour, mercury has been found, rocks of very similar character occur.

The present production of mercury for the use of the world is said to be about 4,000 tons. Its uses in medicine and the arts are numerous, and most of them are well known.

Testimony as to the actual occurrence of mercury or quicksilver in India is not wanting, but, as will appear in each case quoted below, it is defective and unsatisfactory. Still, as the reports have been published, they cannot be safely passed over without reference here.

Madras: CANNANORE.—In the year 1858 Brigadier Fitzgerald reported to the Madras Government[1] the existence of mercury in a bed of laterite at Cannanore. It was stated to occur as the pure metal in small cells in otherwise solid blocks of laterite. Some excavation of the laterite was made in order to test the abundance of the metal, but with what final result is not to be found in any available record at present. Possibly there was some mistake in the identification of the substance.

Afghanistan: PIR KISREE, Lat. 31° 18′; Long. 62° 18′ 30″.—According to Captain Hutton[2] mercury is said to occur in Gurmsael (Garmsir) at Pir Kisree, where it is dug out of the ground. It constitutes an article of Materia Medica and sells at Rs. 2 to Rs. 3 per tola. A report was at one time spread that quicksilver had been found in the Bolan Pass. This proved on enquiry to be true, but the quicksilver, it was afterwards ascertained, was from a broken barometer tube. The cinnabar used in Balochistan is said to come from Persia, India, and Turkey.

[1] *Vide* Engineers' Journal (Calcutta), Vol. I, p. 377.
[2] Cal. Jour., Nat. Hist., Vol. VI, p. 600.

Captain Drummond[1] mentions that a specimen of cinnabar was brought to him once by a villager, who stated that he had found it close to Sultanpur, near Jellalabad, but after an examination of the ground it was concluded that it had been dropped there by accident.

Andaman Islands.—The following statements, especially the two last, afford the principal evidence for the rumour that mercury occurs in the Andaman Islands. They are given here for what they are worth, and that perhaps is not very much. Since the British occupation there has been nothing discovered to justify the belief in the existence of mercury in the islands, though some enquiries have been set on foot, and the natives from different parts have been shown the metal when visiting Port Blair, in the hope that they might recognise it as a product of their islands, but without success. It is possible that some of them might have recognised cinnabar had it been shown to them instead. The rocks of the Andamans are, as has been stated when describing the coal, sandstones, and shales of early tertiary or late cretaceous age with intruded volcanic rocks and serpentine. They apparently have a close resemblance to the rocks which in California now yield a large proportion of the mercury of commerce.

The Mahomedan travellers of the ninth century, having described an island inhabited by a race with the characteristics of the Andamanese of the present day, proceed to say: "Beyond this is a mountainous yet uninhabited island, where it is said there are mines of silver; but as it does not lie in the usual track of shipping, many have sought for it in vain, though it is remarkable for a mountain called Kashenal. It once so happened that a ship sailing in this latitude had sight of the mountains and shaped her course for it, and falling in with the land sent a boat on shore with hands to cut wood. The men kindled a fire and saw silver[2] run from it, which plainly indicated there was a mine of this metal in that place; they shipped, therefore, as much of the earth or ore as they thought fit, but as they were proceeding on their voyage they met with such a storm that to lighten their ship they were under the necessity of throwing all their ore overboard. Since that time the mountain has been carefully sought for, but has never again been seen."[3]

In Hamilton's "East Indies," quoted by Dr. Mouat, we learn that an Andamanese was captured in one of the forays which his countrymen were in the habit of making on their more peaceful neighbours in the

[1] Jour., As. Soc., Bengal, Vol. X, p. 91.

[2] This may possibly allude to the quicksilver mentioned in the following notices.

[3] Harris's Collection of Voyages and Travels.

Nicobars; he was retained in slavery there. Afterwards he was purchased by some Mussulmans of Acheen (Sumatra). His master having died he was manumitted and allowed to set out on a trip to visit his country; this he effected alone in a canoe. Having remained for some time with his friends on the Little Andaman, he returned again to the Nicobars, bringing with him a quantity of quicksilver, which he reported to be abundant. Subsequently he made several voyages to and fro and was seen by the narrator in 1694.

In a list of the useful metals found in India, attached to a letter[1] on the formation of the Museum of Economic Geology for India by Captain Tremenhere to H. Torrens, Secretary to the Asiatic Society, mention is made of quicksilver as occurring in the Andaman Islands, but the authority for the statement is not quoted.

The red pigment ordinarily used by the natives has been analysed and found to be made of oxide of iron; but those who are resident in the islands may yet through the instrumentality of the natives be enabled to discover cinnabar. If the deposit exist in the Little Andaman and there only, its discovery may be a far distant event owing to the notorious hostility and barbarity of the inhabitants of that island.

Aden.—Mercury was first found at Aden by Dr. J. P. Malcolmson, who communicated the discovery in a letter to the Secretary of the Bombay branch of the Royal Asiatic Society.[2] The metal occurred in small globules in a cellular mass of lava which was dug out from a depth of 15 feet from the surface at about 200 yards from the beach. The discovery is stated to have been a *boná fide* one, though some doubt was thrown upon it at the time.

[1] Dated 27th January 1841.
[2] Jour., As. Soc., Bombay, Vol. I, p. 341.

CHAPTER IV.

GOLD—SILVER.

Gold—General remarks.—Although the values of all mineral deposits are apt to be overrated, not only by the general public but also by persons possessing a "little knowledge" of the subject, there is perhaps not one of them with regard to which more unsound and fallacious arguments, or what are supposed to be arguments, are applied than to gold.

It is commonly said of countries where gold-bearing sands are found that there must necessarily be some source where the gold occurs in abundance. By actual and dearly bought experience, no less than by general considerations, the falsity of this conclusion has over and over been demonstrated; but as it continues to be asserted and re-asserted to this day, it will not be out of place, by way of cautionary prelude to what follows, to re-state the grounds upon which the proof that it is an error depends.

There is one point upon which all modern geologists agree, and that is that the subaerial degradation and erosion of the surface by the action of rain and rivers have been going on in the same manner as they do at present, for an enormously long period of time. Huge valleys have thus been scooped out by streams, which, there is reason to believe, were in many cases never larger than they are now. A feeble force acting for a long time, whether the force be physcial or chemical, is capable of producing results so stupendous that the aid of catastrophes is commonly invoked to account for the resultant phenomena. If it be admitted, as indeed it must be, that vast masses of materials have been carried down by streams, their valleys representing the amount of this kind of work which has been done, it cannot be denied that the sifting action of such streams would tend to concentrate the heaviest particles in the nooks and crannies and carry away the lighter ones; this is precisely what explains an apparent abundance of gold in a virgin stream. The gold

may have originally occurred very sparsely disseminated through an enormous mass of materials, but by the concentrating process which has been so long in operation nature has done the heaviest part of the work which the gold-washer completes. He soon finds out, as it has been found out all over the world, that the amount of gold brought down in a single year gives him insignificant returns, and, in time, an area becomes practically exhausted as regards its alluvial gold, though in a country like India, where a man can live for so small a sum, it is possible to derive a subsistence, such as it is, from the washings of a few rivers year after year in succession.

It is a known fact that certain metals occur in solution in sea-water, but it does not necessarily follow that it would pay to extract them. Similarly, many metals occur very sparsely disseminated in rocks and soils. It is a mistake to suppose, for instance, that gold occurs only in quartz reefs ; it often exists in minute quantities in schistose and other rocks, and, perhaps, in the majority of cases it is either absent or only present as a trace even in quartz reefs; so that the mere presence of gold in alluvial deposits does not necessarily prove the existence of a rich source. The man who knows that the value of a sovereign is hidden at a certain depth beneath the surface, and who thereupon expends an equal, not to say a greater, sum in its extraction, is not a wise person. The chance of drawing prizes in the mining lottery causes many people to do what is still more rash and foolish than that attributed to the above imaginary person.

Gold-washing is at present carried on in some parts of the British Islands, and in one particular instance gold is found which is equal in value only to a fraction of the pay of the labourers, who, fortunately for themselves, have a paymaster at their back. In this washing, which is carried on in an enclosed valley in the county of Wicklow, the gold is probably not derived from a reef, but from some schists and slates in which it is probably very sparsely disseminated. The first washings made there in recent times proved the existence of a comparatively large amount of gold in the old alluvial deposits, but when it was exhausted no more gold was to be found in paying quantities, and no reef was ever discovered.

An idea is prevalent among gold and diamond washers that, after a rest, old tailings become again productive in consequence of the growth of the gold and diamonds. The explanation of the fact that rewashing is sometimes productive is, that, in the majority of cases, under the influence of the atmosphere, decomposition and disintegration of envelop-ing minerals and hard crusts take place, in consequence of which the

diamonds or gold are released from their concealment and appear and are collected in the later washings.

As we know so little about the origin of diamonds, it is impossible to speak positively regarding them; but the possibility of gold becoming concentrated in certain spots, and even forming nuggets in alluvial deposits, is now pretty generally admitted, being susceptible of a rational, chemical explanation, as certain chemical solutions, more especially those containing iron sulphate, are capable of holding gold in solution to a small extent. When such a solution comes in contact with decomposing organic matter it is liable to be deoxidised and iron sulphide or pyrites is deposited and with it metallic gold. This process may go on for long periods, and by minute increments the gold may be said to grow; of course, if the gold be included in the crystals of iron pyrites and the latter be not removed by subsequent oxidation and solution, then no actual growth of a nugget can take place; but there is reason to believe that sometimes the gold is deposited free from the entanglement of the pyrites. A case of dendritic gold being found on the rotting timber of an old shaft has been recorded, and in Australia partially fossilised wood has been found in deep leads, under the basalt, with crystals of auriferous pyrites attached. Silica, moreover, when in the halloid condition, is known to be, to a small extent, a solvent of gold; and to this fact, where pyrites is not associated, the presence of free gold in quartz veins may be attributable.

Another possible agency in the concentration of metallic gold is the action of living plants. There does not appear to be any recorded case of traces of gold having been found in the tissues of vegetables; but it is possible that they may be capable of taking up and digesting the greater part of the solutions which contain gold, though they reject the latter as unsuitable. In this way it is conceivable that nuggets may grow by gradual increment, and the possibility being admitted, an explanation is afforded of the curious cases which have been recorded, one of which will be found in the following pages, of gold nuggets having been found enveloped in the roots of plants. Of course some of these cases may have been due to mere mechanical coincidence, but the possibility above alluded to is but one of many instances of the influence which organic life exercises upon inorganic matter.

The ultimate derivation of most of the gold of Peninsular India is doubtless from the quartz reefs which occur traversing the metamorphic and submetamorphic series of rocks, but there is evidence to show that in some parts of the country gold occurs in certain chloritic schists and quartzites, and possibly also in some forms of gneiss independently of

quartz veins. As to the relative productiveness of the reefs in the different groups or series of metamorphosed rocks, the imperfect evidence which at present exists is somewhat conflicting. The truth of the matter probably is that there is no rule applicable to the whole of the country. What may be true in Western Bengal—namely, that in so far as the amount of alluvial gold affords a safe guide, the general productiveness of the submetamorphic to the metamorphic rocks is as 2·5 or 3 to 1—is not necessarily true of other areas.

The presence of gold, either as an original deposit or as a detrital product from the older rocks, has not as yet been proved in any member of the great Vindhyan formation. But in the next succeeding formation several of the groups included in the Gondwana system are believed to contain detrital gold; of these the evidence seems clearest in the case of the Talchir. It is almost certain, however, that the gold obtained in the Godavari and in its tributary near Godalore or Mungapet is derived from rocks of Kamthi age, and the gold of the Ouli river in Talchir in Orissa is derived from sandstones, but whether from those of the Barakar or the Kamthi groups is not certainly known, as both occur in the river section. It is of course natural that the sedimentary rocks which first filled the previously existing hollows and basins should contain gold as well as the other materials derived from the degradation of the older metamorphic rocks, but gold is also probably present, though its existence has not yet been proved, in some of the still younger groups.

In so far as Peninsular India is concerned, the only other sources of gold are the recent and sub-recent alluvial deposits which rest on the metamorphic and sub-metamorphic rocks. Passing to the extra-peninsular regions we meet with evidences of the existence of gold in rocks of several different periods. In Ladak certain quartz reefs which traverse rocks of the carboniferous period are almost certain to be gold-bearing, as particular streams which rise within their limits contain auriferous sands. In Kandahar gold occurs, as also do some ores of other metals in rocks of cretaceous age. Here the deposit is an original one, and is connected with the intrusion of trap.

Lastly, all along the foot of the Himalayas, from west to east, from Afghanistan to the frontiers of Assam and Burma, the tertiary rocks which flank the bases of the hills, and which occur also in the Salt-range and in Assam, south of the Bhramaputra, are more or less auriferous. But this gold is all detrital, and was no doubt, in the first instance, derived from the crystalline metamorphic rocks of the higher ranges which are otherwise known to contain gold. Although it is not incon-

ceivable that exceptionally rich leads might occur in some places among the Siwalik sandstones, the project to search these rocks for productive reefs, of which something has been heard from time to time, could never have emanated from any one possessing the slightest knowledge of the nature of these deposits.

Madras.—The gold-fields of Madras have recently attracted so much public interest and so large an amount of capital that it will doubtless be thought by some readers that they deserve special and exceptional treatment in this volume; but as a matter of fact the available information on the subject at the present moment is much less extensive than might be supposed, and such will continue to be the case until the operations of the companies, now in their infancy, have lasted for some years. The time will then have arrived for writing a history of British gold-mining in India. It is to be hoped that the actual results which can then be recorded will come up to the high standard of success which has been predicted for them.

The pages of the professional mining journals have during the past eighteen months abounded with the opinions of experts who have visited the properties where gold-bearing reefs occur. And so far as is practicable these sources of information have been availed of in the following account. Were it possible to give brief sketches of individual properties an effort might perhaps within certain limits be made to do so; but the necessary information is not available, and even if it were, what is written now would not be up to date six months hence when this volume may be expected to appear. Under the circumstances, therefore, it is possible to deal with the question only from a general point of view. That the industry will itself produce a literature ere long, in which details will be given, is to be expected.

Very interesting are the speculations which have arisen in connection with the discovery of ancient mines in these regions. That there were formerly large hoards of gold in the possession of the ruling dynasties of Southern India has long been known to be the case. Incredible were the accounts of the vast amounts of bullion which were carried away by the Moslem armies of the fourteenth century, and they were naturally enough put down as being the product merely of Oriental exaggeration. Pliny, in A. D. 77, referred to the country of the Nareæ[1] as containing numerous mines of gold and silver, and that by the Nareæ the Nairs of Malabar were meant is now an established fact. The probable position of these silver mines will be discussed on a future page. Dr.

[1] *Nareæ deinde, quos claudit mons altissimus Indicorum Capitalia,* (i.e., Mount Abu) *hujus incolæ, alio latere late auri et argenti metalla fodiunt.*—Nat. Hist., Book VI, Cap. XX.

Burnell has, as the result of his translation of the Tanjore temple inscription, come to the conclusion that in the eleventh century gold existed in extraordinary abundance in Southern India. The arguments used by Mr. Eastwick[1] seem conclusive that the Ophir of Solomon was situated on the west coast of India, and that from thence went the ivory, apes, peacocks, and gold, all of which could not have been obtained from any one country to the west of India.

Coupled with the testimony as to the abundance of gold in the country which is of a most varied kind, there is to be taken into consideration the fact that Messrs. Brough Smyth and Oliver Peglar, as well as many others, have described numerous and extensive ancient mines, which, though they had not escaped the notice of early explorers towards the beginning of the century, have now been brought more prominently to notice than they ever were before. Gold is known to exist in the following provinces and districts of Madras: Travancore, Madura, Salem, Malabar, Wynaad, Mysore, and Bellary. Its occurrence in Vizagapatam seems to be as yet unproven.

Travancore State.—The excitement caused by the recent operations in the Wynaad has led to attention being directed to adjoining areas in Southern India where crystalline rocks occur, and in which it was thought auriferous reefs might possibly be found. Among these areas the Travancore State has to some extent been prospected, and in a map lately published by Mr. Wyld of the gold-bearing regions of Southern India it is represented as an auriferous tract,—upon what authority is not stated, but it may be claimed for this discovery, if true, that it is also new. Travancore does not appear in any of the early accounts as a gold-producing region, and the trade of the gold-washer seems to be there unknown.

Mr. W. King has recently[2] reported on the subject to the Travancore Government. He states that the so-called quartz reefs of Peermerd and the adjoining country are not really reefs, but are the outcrops of beds of quartzite including felspar, which run with the gneiss; only in one case is the outcrop sufficiently large to promise a good tonnage of stone. Although a close assay has detected traces of gold, the amount would not justify the application of the term 'auriferous quartz.' In the Annamalais Mr. King did not observe any reefs so far as he had examined the area, and throughout the northern parts of Travancore he saw nothing to justify a hope that regular auriferous rocks would be found.

A sample from one of these outcrops, which was assayed in Madras, was only about two pounds in weight, so that the amount of gold per

[1] Gentleman's Magazine, Jan. 1880.

[2] Letter to the Dewan of the Travancore, dated 14th March 1881.

ton—2 dwts., 1 grain was calculated from the $\frac{1}{1120}$th. Until a number of assays of large samples have been made no safe conclusions can be arrived at as to the average amount of gold contained in this quartz rock. Mr. King states that an expert was engaged on behalf of one of the Gold Companies in exploring the southern part of the province, and that it was expected that the question would soon be settled for that area.

Madura District.—In the district of Madura gold is found, according to Mr. J. H. Nelson,[1] in two localities, namely, in Palakanuth and in the sands of the Veigei river.

Sir W. Ainslie[2] states that an auriferous zinc blende was discovered in some part of Madura by Mr. Mainwaring.

PALAKANUTH, Lat. 10° 27′ 30″; Long. 77° 50″.—Gold is washed out of the detritus of the granitic rocks which form the Palani hills near Palakanuth. Water is scarce and the work is carried on in a small way, barely affording a subsistence to the washers. The Rev. D. Muzzy[3] is the original authority for these statements. He suggested deep mining in the soil as being likely to give better results.

Lieutenant Nicolson is said to have seen the gold sands of Polygonuth, 45 miles from Dindigul[4]; whether by this Palakanuth is intended is doubtful, since it is only about 12 miles from Dindigul.

VEIGEI RIVER, Lat. 10 °; Long. 78°.—These figures are intended merely to afford a rough indication of position, as the exact spot or spots on the river where washings take place is not recorded. The gold is supposed, like that at Palakanuth, to come from the crystalline rocks of the Palani or Palni hills. The people who search for the gold are called Aruppukarans.

Salem District.—Heyne[5] refers to some gold mines which were at Suttergul, near Pangumpilly, in the year 1802. He was prevented from visiting them owing to a rebellion. They appear to have been either on the borders of Mysore or in the Salem district; probably the latter, but the names are not on modern maps. They were probably not far from Royacottah.

According to Captain Campbell,[6] gold used to be found at the base of a hill called Kanjah Mallia, on the road from Salem to Sankerrydrug. After the rains a number of people washed for it in streams. The earnings of a washer never exceeded eight annas.

[1] Madura Manual, page 30.
[2] Materia Medica of Hindustan: Madras, 1813, p. 54.
[3] Madras Jour. of Lit. and Sci., Vol. XVII, p. 101.
[4] Balfour's Cyclopædia, Art.—Gold.
[5] Tracts, p. 343.
[6] Cal. Jour., Nat. Hist., Vol. II, p. 281.

Malabar District and the Wynaad.—The Wynaad forms a terrace of mountain-land intermediate in position between the low country of Malabar and the lofty plateau of the Nilgiri mountains. It is separated into three portions which are locally known as North, South, and South-East Wynaad. Although the south-eastern division of the Wynaad, in which the principal gold tracts are situated, is now included in the Nilgiri district, it will be more convenient here, with reference to the earliest notices, to treat of it as belonging to the Malabar district, in which it was formerly included.

Probably the first allusion to the existence of gold in this region since the time of Pliny is to be found in the report of a joint commission from Bengal and Bombay, which was appointed to report upon the condition of the Malabar province in the years 1792-93. Allusion is made in the report to the fact that the Raja of Nilambar claimed a royalty on all gold found in his territory. In 1793, too, some steps were taken by Mr. Duncan, Governor of Bombay, to ascertain the value and extent of the gold mines of this region. We next find mention of the fact that gold was worked here in Dr. Buchanan's 'Journey.'[1] He alludes to the existence of gold mines at Malabar in the year 1801, and states that a Nair who had the exclusive right to mine paid a small annual tribute for the privilege. Owing to the disturbed state of the country Dr. Buchanan could not visit the locality.

In the year 1802 Sir W. Ainslie[2] recorded, as elsewhere quoted, several localities in India where gold was then known to occur: among these Nilambar, the Wynaad, and the sand of the Beypur river at Calicut are included. After the lapse of a quarter of a century, or in 1827, Mr. S. Young[3] placed on record that fine specimens of native gold had been found to the west of the Nilgiris in the beds of rivers.

In 1830 Mr. F. H. Barber was examined before the Lords Committee on East Indian affairs.[4] He stated that gold was not only obtained in Coimbatore but throughout the tract of country lying west and south of the Nilgiri and Kunda mountains. He had often witnessed the process of gold-washing and had bought the gold as it was extracted. He estimated the area over which the soil was impregnated with gold at 2,000 square miles. The largest nugget he had seen weighed about half a guinea. The persons employed in washing were the slaves of the proprietors. He attributed the non-improvement in the

[1] Journey through Mysore, &c., Vol. I, p. 441.
[2] Materia Medica of Hindustan. Madras, 1813, p. 54.
[3] Journal, Med. and Phys. Soc. of Calcutta, Vol. IV, p. 48.
[4] Evidence ordered to be printed, 2nd April 1830.

method of searching to the jealousy of the proprietors. The Government derived a revenue from assessing the *puttis* or trays used to wash the gold, but he did not know its amount. He was sure that the proprietors would be willing to sell their lands at such a rate as would make it worth the while of people of capital to take it, but the Government would not allow Europeans to go into the interior without special permission. There were about 100,000 slaves in Malabar; they were bought and sold like cattle, the value of a man being from Rs. 5 to Rs. 20. In some cases their sole clothing was a plantain leaf, and their wretched appearances suggested baboons rather than men. They were originally often kidnapped children, stolen at night from their free parents.

In 1831 Mr. Sheffield, Collector of Malabar, forwarded a report to Government on the localities where gold was known to occur, and on the methods of mining practised by the natives. He had previously for some time purchased gold from these sources on behalf of the Government. In the same year Lieutenant Nicolson was appointed to prospect for gold-fields and also to purchase on behalf of Government. His reports were on the whole sanguine as to the extent of the mines and the possibility of their being worked profitably by the British, and he suggested that stamping-mills with engine power should be set up at Coopal. He proposed that a committee should meet there, as a sight of the mines would do more than anything he could write to ensure conviction as to their value. There are frequent references to the jealousy shown by the natives in reference to his researches and enquiries. The Moplahs refused to take service under him at Rs. 5 a month, as they said they would have to work daily for him while the gold they could find in one day sometimes enabled them to live in idleness for a week. At Nilambar the mines were worked by Korumba slaves who were subjected to horrible cruelties if the gold they found was deficient in quantity.

The report was accompanied by a map showing the positions of the mines, on which it is stated that the largest mines were at Coopal and Carembat. After receipt of the Report of a Committee in 1833, which condemned working in the low country of Malabar as a European industry, the Governor in Council came to the conclusion that it would be inexpedient to work the mines, and Lieutenant Nicolson returned to military duty.

Reports and letters by the Collector of Malabar in 1857 and 1858 directed attention, after another period of a quarter of a century, to these gold mines, which extended for a distance of 30 or 40 miles along the western faces of the ghâts and also in some places to their summits. The taxes payable by the Rajas for the right to mine had fallen into

arrears; apparently many of the older miners and their descendants had migrated to the coffee plantations of the Western Wynaad.

In the year 1865, according to Mr. Brough Smyth, among those who were attracted to the Wynaad were Mr. H. L. Sterne and Mr. G. E. Withers, both of whom had had experience of Australian gold-mining. Soon after, the enterprise of Mr. J. W. Minchin led to the erection of machinery to crush the quartz at the Skull reef. Other applicants for the right to mine on their estates then came forward. It would be impossible in this account to give the details of these earliest efforts to put the matter to a practical test or of those which followed in 1875 and 1876. Their want of success has been fully described by Mr. Brough Smyth. Early in 1875 Mr. W. King,[1] Deputy Superintendent of the Geological Survey, visited the Wynaad and soon after his report and map were published.

The principal rocks of the area are granites, gneisses, and other forms of metamorphic rocks which are traversed by numerous quartz reefs. The gold he describes as occurring originally in the reefs or large lodes of quartz, in the leaders or spurs from them, and in the casing rock. In the leaders and casing the gold is generally visible, either segregated in the interstices of the quartz or included in the pyrites or the cubes of the same altered into limonite. Invisible gold also occurs with pyrolusite. In the reefs the gold is generally fine.

The quartz reefs are without exception white at the outcrop, so that it is impossible to say from a surface inspection whether they are auriferous or not. This is the case with the skull reef of the Alpha Company. The prevailing direction of these reefs is from north-north-west to south-south-east, but owing to the irregularity and the occasional flatness of the underlie it is not always easy to trace them individually, but the Monarch reef appeared to be traceable for nine miles.

Mr. Brough Smith's report on the Wynaad gold-fields gives an account of his explorations during the years 1879 and 1880. In the tract to which he gave his particular attention, and which covers 500 square miles, 200 outcrops, not necessarily distinct reefs, were counted; they are stated to be more numerous, proportionately richer and wider, than in almost any portion of Australia. As had previously been pointed out by Mr. King, there are no deep leads or accumulations of drifts such as characterise the Australian fields. The ancient mines indicate different degrees of knowledge in the miner's art. They consisted of—1, quarrying on the outcrops of veins; 2, vertical shafts; 3, adits; 4, vertical shafts with adits; 5, shafts on underlie. Among these the most remarkable are the vertical

[1] Records, G. S. I., Vol. VIII, p. 29.

shafts; they are even when in solid quartz sometimes 70 feet deep, with smooth and quite plumb sides. What the tools were which enabled the miners to produce such work in hard dense quartz no one appears to be able to suggest. The fragments of stone obtained from these various mines were pounded with hand-mullers, the pounding places being still seen, and the pounded stone was then, it is believed, washed in a wooden dish and treated with mercury.

Mr. Brough Smyth compared the present condition of the country to an abandoned Australian washing, it being covered over with tailings owing to the industry of the Korumbas. Even still, however, streaks of fine gold may generally be found on washing a few dishes of the surface soil, and "in the vicinity of the reefs rather heavy gold is got by sluicing, and, if a suitable spot be selected, the native miners will obtain, even by their rude methods, sufficient gold to remunerate them for their labour."

The assays of quartz available at the time, and which had been made by himself, by Mr. Tween in the laboratory of the Geological Survey office, and by other analysts, numbered 137, of which the following is an abstract:—

Name of Reef.	Ples assayed by: Mr. B. Sm	Other analy	Total	Average y eld of gold per ton: oz.	dwts.	grs.	Remarks.
Alpha Company's works	0	6		0	9	16	
Skull reef workings		10		3	3	10	One out of the 17 cases had no gold.
Wright's level	11	7	18	18	9	1	Out of the 18, two showed fine specks of gold and one assay was lost.
Prince of Wales' reef	6	0		0	3	12	
Cavern reef	13	1		0	18	21	
Korumba reef	1	8		1	3	1	Out of the nine, one had traces of gold.
Bear "	4	4		0	11	18	Out of the eight, one had no gold and one had few minute specks.
Hamslade "	1	4		0	6	13	Out of five, one had minute particles of gold.
Dawson's "	3	0		0	12	9	
Karambaut "	4	0		0	12	15	Out of four, one had specks of gold.
	50	40		2	13	2	

If from the above an exceptional sample from Wright's level, which gave 204½ oz. per ton, be omitted, and also picked specimens from the same workings which gave 25½ oz. per ton, we get 88 samples yielding an average of 1 oz. 8 dwts. 22 grains per ton.

As to the quality of the gold, it has been found to be unequal, that from the soils (alluvial) being finest.

Two samples of surface gold obtained by Mr. King were assayed in Calcutta and yielded—

	No. 1.	No. 2.
Gold	93·	90·90
Silver	7·	8·67
	100·	99·57

The average of six assays of reef gold gave—

Gold	86·86
Silver	10·96
Dross	2·18
	100·

Such subjects as the climate, water and timber-supply, &c., are fully dealt with, and also the very important question of mineral rights is discussed. Since the Government have taken up this latter the matter is now, it is believed, on a more satisfactory footing, they having determined to make the terms of the mining leases as simple and liberal as possible. It is not proposed to levy an y royalty or other tax on the industry for the present, because it is deemed most important to attract capital to the gold-fields. The pioneers will have to buy their experience in many directions, and it is undesirable that the first ventures should be unsuccessful.

Mr. Brough Smyth, in a special report to Government, discussed the cause of failure of the Alpha Company. The machinery and the management were both unsuited to the requirements of an economical system, yet, in spite of these, the gold obtained was from 779½ tons 2 dwts. 9 grains and from 32,266 tons 10 dwts. 12 grains per ton.

In his concluding remarks he speaks with confidence as to the future of the industry, and says that failure can only result from want of care and forethought as the resources are large.

The following estimate of the cost of working a company by Mr. Jer. Ryan[1] may prove both interesting and useful. It is stated to be based on actual experience, but no means of confirming its accuracy or otherwise are available at present.

[1] Pamphlet: Kensington and Co., London.

It being assumed that a concession of value cannot be now obtained at a less cost than £60,000, the following would represent the first year's expenditure:—

Price paid for concession	£60,000
Cost of machinery, 100 Stamp-heads at £200 each . .	£20,000
One year's working expenses	£12,000
Contingencies, law charges, &c.	£8,000
Total amount of Capital	£100,000

Taking the value of gold at £3-15 the ounce, the return from 25,000 tons of stone, containing from 3 to 10 dwts. of gold per ton, would be as follows:—

	Total of ounces.	Value at £3-15.		Cost of production. [1]	Profit.		Percentage on Capital of £100,000.
		£	s.	£	£	s.	
If yield is 3 dwt. per ton.	3,750	14,062	10	11,875	2187	10	2·19
" 4 " "	5,000	18,750		11,875	6,875		6·87
" 5 " "	6,250	23,437		11,875	11,562		11·56
" 6 " "	7,500	28,125		11,875	16,250		16·25
" 7 " "	8,750	32,812	10	11,875	20,937		20·93
" 8 " "	10,000	37,500		11,875	25,625		25·62
" 9 " "	11,250	42,187		11,875	30,312		30·31
" 10 " "	12,500	46,875		11,875	35,000		35·00

Mysore Province.—In the year 1802 Captain Warren,[2] then engaged in the survey of the eastern frontiers of Mysore, in the Kolar district, hearing of a rumour that gold had been found at the Yerra Baterine Hill, instituted enquiries which led to the discovery that there were gold-washings near the village of Wurigam, the modern Urigam or Ooregaum, and actual mining at Marcurpam, the quartz which was taken out being pounded into dust by women and then washed.

An Amildar informed him that Tipu had formerly sent a Brahmin to work the mines, but as the cost equalled the outturn they were given up. But the rayats said that this Brahmin had never personally visited the mines. He mentions that in 1800 he had been told in the village of Cargury, on the Poni-aur, that in prosperous years, when there was an ample harvest, grains of gold were sometimes found in the ears of paddy growing below a tank. This sounds like a metaphor and suggests chaff. Captain Warren regarded it as a fabrication at first, but subsequently,

[1] This sum is arrived at as the average of several estimates of cost—25,000 tons at 9 *s.* 6 *d.* = £11,875.

[2] Jour., As. Soc., Bengal, Vol III, p. 463. An abstract of this paper is given in the Mysore and Coorg Gazetteer, Vol I, p. 34.

his attention having been drawn to the existence of gold at the other localities, he proved its presence here by the aid of washers from Wurigam, and thought there might have been something in the story. Paddy, however, has not ears like wheat or barley, and it seems incredible that the rising plant should be able to carry up grains of gold from the soil. It would appear from his descriptions that the laterite is auriferous, a very probable contingency where it is of the detrital character. Over an extended area, about the Manigatta, Wullur, and Yeldur Hills from Budikote to Ramasamudra, Captain Warren proved the presence of gold in the surface soil and in the beds of rivers. The people who washed were Dherus or Pariahs, and he seems to think that agriculture was for them a more profitable profession.

The description of two mines then follows, one at Kembly, 30 feet deep and with a gallery of 50 feet; the other west of Surunpally, which was 45 feet deep and 56 feet in extent. It is evident from the sections given that these were not in solid rock, but masses of quartz in an ochreous matrix were taken out to be crushed. Heyne alludes to Warren's researches, but speaks of the gold as being only found in small quantities. Specimens of gold *in situ* from this region appear to have been collected from time to time by Captain Arthur, Lieutenant Puckle,[1] and Dr. Orr.[2] Owing to accidents in these deep alluvial mines, General Sir Mark Cubbin, when Commissioner of Mysore, is said to have prohibited any more being sunk. Recently it has been asserted that Tipu had a mint for gold coin in the neighbourhood of Ooregaum. If he had, it is strange that Captain Warren did not refer to it.

The recent growth of the gold industry in this province can only be gathered, in part, from the following statements in successive Administration Reports. In 1868 it was stated that alluvial gold was occasionally found near Betmangla, but in too small quantities to repay labour. In 1870 it is said that washers earn 4 annas a day by washing at the foot of the Hemagiri Hill, in the Huliyurdurga taluk of the Nandidrug division. In 1872-73 four pounds weight of gold was found in the Betmangla taluk. In 1873-74 six pounds weight of gold was obtained in Kolar, and an opinion is expressed that a proper system of working would prove the existence of a considerable quantity of gold in certain districts. In 1874-75 three pounds weight of gold was obtained in Kolar and 20 rupees worth in the Honuali taluk of the Shimoga district. Permission to prospect for gold and other metals was granted to Mr. Lavelle for three years. Leases for twenty years would be granted to him for blocks

[1] Balfour's Cyclopædia, Art.—Gold.
[2] Indian Economist, Vol II, p. 210.

not exceeding 2 square miles each in extent, and ten in number. The report for 1875-76 states that the terms of the leases had been modified and that prospecting was progressing. In 1876-77, the Urigam or Ooregaum Company is referred to as not then having commenced operations.

In the reports for 1877-78 and 1878-79 there is no information, and in the table on mines and quarries the statistics of iron, stone, and gold are lumped together. In the last report, 1879-80, gold is not alluded to except in a similar table, though it is stated that iron and potstone are the only minerals worked in the province.

Some information on the gold of Mysore will be found in the Gazetteer of Mysore and Coorg, but most of the facts are derived from the sources of information given above. It is stated, however, that platinum has been found with the gold in the washings, and that the experimental crushing of some quartz was reported to have given a return of six ounces of gold to the ton.

It is known that the rocks of Kolar, and probably of the whole of Mysore, belong to the metamorphic or crystalline series, but there has not yet been any detailed geological survey. It is stated that there are numerous quartz reefs,[1] and that 17 tons of quartz crushed on the property of one of the companies yielded 2 oz. 8 dwts. of gold per ton, the silver alloy in the gold being 7½ per cent.

If this rate of production, or perhaps even half of it, should continue, it is possible that those among the half dozen companies which have recently been started in Mysore, whose management is good and whose preliminary expenditure has not been too heavy, have a profitable career before them. The climate, at the average elevation of 3,800 feet, is said to be equal to that at Bangalore; there is a line of railway close by, and labour and water are abundant.

Bellary District.—Dr. Balfour[2] states that there is a report to the effect that gold was found in streams near Camvehully, and at a hill bearing the name Jageraculiy, Goodda, &c.

The Bellary Manual by Mr. J. Kelsall does not, however, contain any reference to the real or supposed existence of gold among the minerals found in the district.

Hyderabad or Nizam's Territory.—The occurrence of gold-dust in the bed of the Godavari has long been known, and mention of it is found in several works published about the beginning of the century.[3]

[1] Mining Journal, Vol. I, 1880, pp. 924, 950.

[2] Cyclopædia, Art.—Gold.

[3] Oriental Repertory, Vol. II, 1808, p. 472; and Materia Medica of Hindustan, by Sir W. Ainslie, 1813, p. 54.

According to Dr. Walker,[1] there was a gold mine about the year 1790 near the village of Goodloor or Godalore, near Mungapet, where the Kummamet and Ramgheer Circars meet, which had been profitably worked by the Paluncha Raja. At the time of his visit he could hear nothing locally of this mine, but learnt that washing had been carried on comparatively recently in the streams which feed the Godavari from the south. It was the custom to place bunds across the streams, and after the rains had ceased to wash the sand so arrested. The washers belonged to a peripatetic race, who were employed by a rich Bania. Owing to an excessive rent charged by the Raja, operations ceased and had not been resumed.

In the account on a following page of the gold-washings of the Upper Godavari district of the Central Provinces the gold alluded to is really brought into the Godavari by streams in Hyderabad territory, and in fact this Godalore must have been near to and derived its gold from the same sources as Marrigudem (or Marriguram). As there are no crystalline rocks in the neighbourhood, it is improbable that there ever was a real mine here. The gold must have been doubly derivative from Kamthi rocks.[2] It is perhaps therefore needless to add that gold in quantity is not likely to be found at this locality.

Orissa.—Within the limits of the province of Orissa gold-washing is or has been carried on in the Native States of Dhenkanal, Keonjhar, Pal Lahara, and Talchir. It is a poor pursuit, as in so many other parts of the country, but the fact is interesting as affording evidence of the existence of gold.

DHENKANAL TOWN, Lat. 20° 42′; Long. 85° 34′.—Mr. Stirling[3] alludes to a report that gold is found in some of the streams of Dhenkanal, and in the Statistical Account of Bengal[4] washing for it is said to take place in them to a small extent. There was no washing going on there in the early part of the cold season of 1875-76 when the writer passed through the State. The rocks chiefly belong to the older metamorphic series, but there are also some Gondwanas.

KEONJHAR, Lat. 21° 37′ 30″; Long. 85° 34′ 15″.—The evidence of gold-washing being practised in Keonjhar is identical with that given for Dhenkanal. There is reason for believing that in Keonjhar both metamorphic and sub-metamorphic rocks occur.

[1] Madras Journal of Lit. and Sci., Vol. XVI, p. 183.
[2] Conf. King, W. Mem., G. S. I., Vol. XVII.
[3] As. Res., Vol. XV, p. 179.
[4] Vol. XIX, p. 203.

LAHARA TOWN, Lat. 21° 22′; Long. 85° 11′.—In the Brahmini river, where it traverses Pal Lahara, gold-washing is carried on somewhat more actively[1] than in the abovenamed States. Further north, in the bed of the Brahmani, in the Bonai State of Chutia Nagpur, there are also gold-washings, as will be duly noted on a future page.

TALCHIR, Lat. 20° 57′; Long. 85° 13′ 30″.—Within the limits of the Talchir State gold has been washed for to a small extent in the Brahmani and its tributaries, especially in the Tikaria and the Ouli. In the former case it is probably directly derived from metamorphic rocks, but in the latter it must have a doubly derivative origin since the Ouli flows through coal-measure Gondwana rocks, namely, Kamthis and Barakars.[2]

Bengal: Midnapur District.—In the Midnapur district there were 21 professional gold-washers according to the census returns. There is no published record of the actual spots where washing is practised, but they must be situated in the beds of the Kasai (Cossye) river and its tributaries. Throughout the greater part of the district deposits of alluvium and laterite prevail, but the older crystalline and the sub-metamorphic rocks are exposed on the western frontier which adjoins Manbhum and Singbhum.

In the year 1855 a sample of gold-dust from Midnapur, which was forwarded by Lieutenant W. D. Short, Executive Engineer, was examined by Mr. Piddington,[3] who discovered in it some particles of a yellowish-white mineral, which was "malleable and tough, would not amalgamate with mercury, and was excessively difficult of solution in boiling *aqua regia*, though it certainly contained gold." He was inclined to believe that it might be a sulphuret of gold, an unknown mineral, but thought he detected a trace of platinum. Further and larger specimens which he applied for he does not appear to have received.

Bankura District.—Gold is reported to have been obtained in very small quantities in the sands of the Dalkissur at Bankura, and the statement is not improbably correct.

The absence of any record as to the occurrence of gold in the districts comprised in the Bhagulpur Division is very remarkable, as *primâ facie* the character of the geology in several of them would justify one in suspecting its presence.

Chutia Nagpur Province.—The Chutia Nagpur Province includes the greater portion of the hilly region on the south-west frontier of

1 Jour., As. Soc., Bengal, Vol. VIII, p. 1058; Mem., G. S. I., Vol. I, p. 88.

2 *L. c.*

3 Jour., As. Soc., Bengal, Vol. XXIV, p. 250.

Bengal. It is sub-divided into the following four British districts and seven tributary States: Hazaribagh, Manbhum, Singhbhum, Lohardaga: Bonai, Chang Bhakar, Gangpur, Jashpur, Korea, Sirguja, and Udepur. From the characters of the rocks found in each of these sub-divisions respectively, it is not improbable that gold occurs in all of them. Whether because it is less abundant in some, as is probable, or because it has never been properly searched for, the fact is certain that in others there is a greater attraction for the indigenous gold-seekers. Judged by this standard, which is the only one at present available, the richest tracts are situated in Manbhum, Singhbhum, Gangpur, Jashpur, and Udaipur.

That these, or some of them, may yet be the scene of extensive operations, should the gold-mining in Southern India be successful, is very possible. The indications afforded by the alluvial deposits, of sources of gold existing in the rocks over several large areas, are perhaps quite as striking in their way as those which have led to the starting of the gold-mining industry in Southern India. Quartz or reef mining and crushing, however, can scarcely be said to have been tried in this area, but one solitary and not very extensive attempt having been made.

Hazaribagh District.—There does not appear to be any published record of gold having been found in this area, and properly speaking it ought not to be included in this list. But it is impossible not to believe that properly conducted operations would reveal its presence.

Manbhum District.—The localities where gold-bearing sands exist in Manbhum are very numerous; indeed, in the southern half of the district there are probably few streams in which gold, if searched for, would not be found.

By the systematic application of the operations of two gold-washers during a period of three months throughout this southern tract, the writer[1] was enabled to define the area in which the gold was most abundant. This result not only agreed with the traditional knowledge possessed by the gold-washers, but it was found that the area in which gold was comparatively most abundant corresponded precisely with a tract in which a particular series of rocks occurred. These rocks, consisting chiefly of magnesian and mica schists, slates, and quartzites, are included in the sub-metamorphic series; but although gold was most abundant in the superficial deposits within this area, those of the other portions of the district, where metamorphic rocks are alone present, did not prove quite barren; in fact, the largest piece of gold found, and which weighed 1·9 grains, was obtained in deposits derived from granitic gneiss rocks near the village of Bhagmundi.

[1] Records, G. S. I., Vol. I, 1869.

The boundary between these two formations has an east to west course, which roughly corresponds to the position of the 23° 5′ parallel of north latitude. Otherwise, and more nearly, it may be said to coincide with a line drawn from Simlapal on the east through Bara Bazaar to a point a little north of Ichagarh on the west, and so on into the Chutia Nagpur highlands. South of this line the sub-metamorphic rocks almost exclusively prevail, and beyond the Manbhum frontiers they continue into Singhbhum aad Lohardaga, where they maintain the same characters as regards their comparative richness in gold.

During the period above alluded to a record was kept of the daily results and of the nature of the rocks in which the washings were made. The following abstract will suffice for comparison of the productiveness of the two formations :—

Sub-metamorphic Rocks.

	Jan.	Feb.	March.	April.	Total.
Number of days on which washings were made .	31	9	18	8	66.
Unsuccessful days . .	2	3	2	2	9=13·6 per cent.
Total gold in grains . .	17·68	4·65	7·6	2·45	32·38.
Daily average ditto . .	·57	·516	·4	·3	Daily average for whole period $= \frac{32\cdot38}{66} = \cdot4$ grains.

Metamorphic Rocks.

	Jan.	Feb.	March.	April.	Total.
Number of days on which washings were made .		20	13		33.
Unsuccessful days . .		13	9		22 = 66 per cent.
Total gold in grains . .		4·78	·7		5·48.
Daily average ditto . .		·23	·05		Daily average for whole period $= \frac{5\cdot48}{33} = \cdot16.$

Comparing the results by the number of successful days first, we may say that for gold-producing the sub-metamorphic rocks are to the metamorphics as (100—13·6=)86·4 to (100 – 66=) 34=2·5 : 1; comparing by daily average, the proportions become ·49 : ·16=q. p. 3 : 1. We may therefore conclude that the sub-metamorphics are between two and a half and three times as productive of gold as the metamorphics, so that as the gold-washers only find a subsistence from washing in the

sub-metamorphic area, it is obvious that it would not pay them to work in that occupied by the metamorphics.

The actual amount of gold found was, it will be observed, very small, but the washers were often working on strange ground; and moreover they generally had to make a march of some miles before arriving at the scene of their operations, to which must be added also that their days' wage being certain, they generally contented themselves with a very limited amount of physical exertion.

The rivers which contain most gold in this area are the Subanarekha and its tributaries, the Karkari and Bamni, on the west of the area, and the Kasai and its tributaries, the Tutko and Kowari, on the east. Besides these, many of the streams in the neighbourhood of the Dalma hill range and in the Supur pargana might be enumerated.

In Supur, near the village of Namra, Lat. 22° 54′ 30″; Long. 86° 36′, there is an excavation supposed to have been a gold mine, and it is so indicated on the map. The natives had some rather vague tradition of images of gold and silver bulls having been found there. Close by, gold is said to be found in scrapings from the roads which are washed on a small scale by the *Dhoras* or *Dokhras* (=Jhoras) during the rains.

Gold-washing was tried by a European a few years ago on the Karkari river, near Ichagarh, Lat. 23° 2′ 15′, Long. 86,° the chief town of Patkum, but with what measure of success is not known. The process of gold-washing in practice in Manbhum is identical with that in Singhbhum, and need not, therefore, be separately described.

Singhbhum District.—In Singhbhum gold occurs in very much the same manner as it does in Manbhum, the gold-bearing rocks being in unbroken connection throughout and forming one united tract, with this difference, that in Singhbhum, so far as is certainly known, the sub-metamorphic rocks alone contain gold. These rocks surround a trap-traversed area of old granitic gneisses, which are probably older than the general metamorphic rocks of Manbhum; these latter are also represented in the western highlands of Singhbhum, where they, too, are possibly auriferous, but to a less extent than the sub-metamorphics.

In Manbhum quartz reefs are not abundant in the sub-metamorphic rocks, and the washings seemed to point to the magnesian schists, and certain bluish quartzites as being the sources of the gold. In Singhbhum, especially to the north and west of Chaibassa, quartz reefs are abundant in some earthy shales and slates, and it seems probable that they may prove to contain gold. The only nugget seen by the writer in Singhbhum was in a quartz matrix, and gold is said to have been obtained by quartz-crushing at Landu.

The most noteworthy places where gold has been found in Singhbhum are Kamerara and the Kapargadi ghât in Dhalbhum, Landu in Seraikela, Asantoria in Kharsawan, Sonapet, Porahat, and Dhipa in Sarunda.

Before giving the known details regarding these localities, it may be well to describe the gold-washers and their operations, it being understood that they apply equally to those of Manbhum, and indeed, with local modifications, to all throughout the greater part of Peninsular India.

The class who more particularly follow the trade of gold-washing belong to a tribe of Gonds known as Jhoras, Dhoras, Dokras, Toras, or Jharas, according to locality. The name Jhora is said to be derived from *jhori*, a small stream, but Dhora may be derived from *dhona*, to wash. In the case of these people both sexes engage in the pursuit, but the Ghasis, a local tribe of unknown origin, also occasionally wash for gold. Among them the men only, while among certain Kol or Munda tribes to the west of Singhbhum the women wash for gold, while their male relatives regard the work as an unworthy occupation for their sex. The methods employed by these different tribes appear to be identical in all essentials. Each occupies a distinct tract, and poaching on one another's favourite streams is not indulged in to any great extent.

The wooden dish used for washing measures on an average about 28 by 18 inches for the men, smaller ones being used by the women and children among the Jhoras. The dish is hollowed somewhat eccentrically to a maximum depth of 2½ inches. A scraper formed of a flattened iron hook, set in a handle, is used to collect the auriferous sand and gravel which accumulates in the angles formed by the rocks in the beds of the stream. The dish when filled is placed in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions. The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron sand in which the specks of gold are readily apparent; but as mercury is not employed in this part of the country, all the very small and invisible gold is lost. The illustration Plate IV will probably enable the reader to realise the appearance presented by these gold-washers when pursuing their trade.

The daily earnings of the gold-washers are small, but might, no doubt be increased if it were not that they are always satisfied when enough gold

has been found for procuring the day's subsistence. Colonel Haughton in 1854 stated that the Ghasis could always reckon on earning from three to four pice per day; he was assured that a vigorous man often got as much as twelve annas, which, as the ordinary rate of field labour was about one pice, must be considered a very large sum.[1] Mr. Robinson found, in a trial which he made at Rabkob, in Udepur, that men to whom he paid one anna could produce for him from three to four annas worth of gold. Colonel Dalton states that the washers themselves regard it as a very poor trade, simply yielding they say *pét bhur* (bellyfull). Dr. Stœhr, in his paper on Singhbhum, recorded that he found the average daily earning to be about 25 centimes (rather more than an anna and a half). The men met with by the writer stated that they could earn about an anna a day and occasionally three or four annas.

Kamerara, Lat. 22° 15′; Long. 86° 43′ 30″.—According to Colonel Haughton, gold has been found in the bed of the Subanarekha at this locality, which is on the eastern margin of the rocky tract. He states his belief that the sands of this river continue to contain gold from thence to the sea.

Kapargadi Ghat, Lat. 22° 39′; Long. 86° 23′.—A nugget of gold shown to the writer when in Singhbhum was said to have been found close to the pass on the Midnapur road through the Kapargadi hills.

Landu, Lat. 22° 43′ 30″; Long. 86° 15′.—At Landu and various other places the copper ores, which will be described on a future page, were found to be auriferous to a small extent.[2]

A Mr. Emerson was employed by the Singhbhum Copper Company specially to investigate the gold resources of the country. He is said to have crushed a quantity of quartz, but there is no available record as to the results which he obtained.

Asantoria, Lat. 22° 44′; Long. 85° 51′.—At Asantoria or Assuntullea gold is said by Colonel Haughton to occur *in situ*, but it appears from the context that it is not to be understood that it was actually found in the rock there, but the locality being higher than the neighbourhood it was concluded that the matrix was close by. Dr. Stœhr mentions gold-washings at Baritopa, in the neighbourhood of Kharsawan.

Sonapet, Lat. 22° 53′; Long. 85° 44′ 30″.—Sonapet, or the 'mother of gold,' is the valley of the Sonai river to the north-west of Kharsawan. All writers on the district refer to it as containing more gold than other parts of the district. Some years before 1854 nuggets

[1] Jour., As. Soc., Bengal, Vol XIII, p. 110.
[2] Viertel. der Nat. Ges. in Zurich, Vol. V, 1860, p. 353.

were found there according to Colonel Haughton,[1] but the finder never divulged the secret of the exact spot.

PORAHAT, Lat. 22° 36′; Long. 85° 30′.—Colonel Haughton[2] alludes to a tradition of a regular gold mine having been driven into the side of a hill in the jungles of Porahat. No trace of this mine remains at present. Gold-washing is carried on in the streams of Porahat by the women only of the Munda inhabitants.

SARANDA.—In Saranda, which is a hilly elevated tract in Singhbhum, intervening between the main area of Singhbhum and Gangpur, gold is washed for to some extent. Its occurrence in Anandapur and at Arabhanga is recorded by Colonel Haughton.[3] The latter name does not appear on the map, but close to the former, at Dhipa, gold-washing was witnessed by the writer.[4]

DHIPA, Lat. 22° 26′; Long. 85° 15′.—The bed of the Koel river near Dhipa yields a small amount of gold. The pay dirt was scraped out from the nooks and crevices of some protruding rocks. Both sub-metamorphic and metamorphic rocks occur in this region. Colonel Haughton on his map represents the beds of the Koel, Karo, Sunk, and the Brahmini, which is formed by the junction of the three, as gold-bearing, and they are so no doubt to some extent.

Lohardaga District.—The Kanchi river, in Lohardaga, contains gold-bearing sands, which are derived probably from the same series of rocks as those included in the adjoining auriferous tract of Manbhum and Singhbhum. There are reports of gold having been found in the Sone river on the frontiers of the Palamow sub-division, but there are no published notices on the subject.

Bonai State.—BONAI TOWN, Lat. 21° 49′; Long. 85° 1′.—As already mentioned, gold occurs and is washed for in the bed of the Brahmini in Bonai.[5]

Gangpur State.—Within the limits of this State gold-washing takes place in the bed of the Ebe and in those of some of its tributaries, more particularly in the Icha, as is indicated on the topographical survey map; Lat. 22° 6′ 30″; Long. 83° 55′ 30″. This gold-bearing region adjoins those next described in Jashpur and Udepur.

Surgeon Breton, in his paper quoted already, in reference to the diamonds of this region, states that there were gold mines in Gangpur

[1] *L. c.*, p. 111.
[2] *L. c.*, p. 107.
[3] Jour., As. Soc., Bengal, Vol. XXIII, p. 107.
[4] Jungle Life in India, p. 481.
[5] Statistical Account of Bengal, Vol. XVII, p. 167.

and Jashpur just large enough for a man to descend, but of considerable extent below. In the Gangpur mine, an account of which was to be submitted, large pieces of pure gold were stated to have been found.[1]

There is no record of any gold-washing being carried on in Korea and Chang Bhakar States, and although gold is enumerated in a list of the products of Sirguja by Colonel Ouseley,[2] it is not sought for there at present.

Jashpur State.—Colonel Ouseley,[3] when forwarding to the Government specimens of gold for assay, specifically mentions the village of Pharsabahal as the locality from whence they were derived. Other authorities are less precise, and indeed it is not quite clear whether portions of the following remarks refer to Jashpur or to Udepur.

Mr. Robinson, in a letter[4] dated December 1849, speaks of shafts sunk to depths varying from 20 to 60 feet, and which are very close to one another as the people are afraid to run galleries. In places the ground resembles a gigantic rabbit warren. Sometimes these old gold-bearing alluvial deposits crop out in the banks of the rivers. Besides washing for the gold in the ordinary wooden dishes, the people here arrange small water-courses before the rains so as to catch the soil in which a large proportion of gold is found; these are cleared out from time to time. Mr. Robinson writes that the late Raja of Jashpur, Ram Singh, had worked these mines with success, but owing to an accident in one of the shafts, by which a number of people lost their lives, operations ceased. His son, the then Raja, considered such work beneath his dignity. Mr. Robinson states that the Government at the next settlement (in 1850) intended to reserve the mineral rights to themselves, and he purposed applying for a lease, having no doubt that he would be able to get one for a good term of years, believing that these mines must pay splendidly. The late Colonel Dalton[5] gives a very full account of the operations of the Jhoras or gold-washers of Jashpur. They find it more profitable to work the ancient deposits than to wash the sands of the river beds. On both sides of the Ebe or Ib river there are tracts at some distance from the banks, which are honey-combed, with shafts sunk by successive generations of gold-seekers. These shafts are from 10 to 30 feet deep. The gold-bearing statrum is a layer of pebbles and fragments of quartz which underlies red soil and vege-

[1] Medico Topography of Ceded Provinces, 1826.
[2] Jour., As. Soc., Bengal, Vol. XVII, 1848, p. 65.
[3] *Idem*, Vol. XXIII, p. 110.
[4] *Idem*, p. 107.
[5] *Idem*, Vol. XXXIV, Part II, p. 13.

table humus. The stuff selected is of a dirty drab or reddish colour with occasional balls of decomposed felspar, which latter are regarded as the surest indication of the presence of gold. The decomposed granitic rock upon which this layer reposes is not generally washed, but Colonel Dalton found that it was likewise auriferous but to a less degree.

Five shafts were in operation, one family to each, as the women and children assist, and each family has its *duin* or washing-dish. Accidents occasionally happen from the falling-in of the shafts.

The yield is very uncertain. The outturn from the five shafts obtained during four hours in Colonel Dalton's presence would not have given more than half an anna a head to those employed, but occasionally as much as half a tolah, or say Rs. 6 or Rs. 7 worth of gold was obtained, according to the statements of the washers. No mercury was used, only the visible gold being saved. The particles were angular and not worn by attrition. As is commonly the case, these men were much indebted to the money-lenders, one being pointed out as owing Rs. 1,000.

Colonel Ouseley's locality, above alluded to, is

PHARSABAHAL, Lat. 22° 30′; Long. 83° 55′ 33″ (A. S., 105, S. W.) From this locality, which is about 4 miles to the west of the Ebe, Colonel Ouseley forwarded Rs. 11 weight of gold obtained from mines. Each village is bound to pay a certain weight of gold annually to the Raja, the heads of villages (Tikadars) buying from the Jhoras and paying for it in rice. The following reports on all the gold forwarded by Colonel Ouseley were issued by the Mint Master, Colonel W. N. Forbes :—

Quantity received.			Base alloys.	Pure Contents.		Assay.	Intrinsic produce in tolas or new standard of gold mohur.
				Silver.	Gold.		
				In 100 parts.			
1	2	6	4·047	8·062	87·891	$3\frac{3}{8}$ Ws.	95·888
0	8	0		7·031	92·969	$1\frac{1}{4}$ Bt.	101·420
10	14	0		12·079	88·021	$3\frac{1}{2}$ Ws.	96·023

Mint Register. No.	Description.	Tale.	Weight in tolahs.			Assay.	Assay produce in gold mohurs.		
1847. 27th August, 545	A gold ingot from gold lumps and dust.	...	12	0	3	$1\frac{1}{4}$ Rs.	12	4	4
						Goldmohurs	12	4	4
			12	0	3			or	
						Co's. Rs.	181	1	0

A few years ago the Geological Survey Museum received from Colonel Dalton a nugget which was obtained in Jashpur. It weighed on receipt 221·87 grains, and after cleaning 199·6 grains. On assay 13·562 grains gave—

Gold chloride	12·836	=per cent.	Gold	94·64
Silver „	0·93		Silver	5·15
				99·79

The specific gravity was 15·24. The facts just given and those mentioned below, with reference to the States of Gangpur and Udepur, establish beyond a possibility of doubt the existence of an ancient alluvial gold-bearing deposit at intervals throughout a tract not far short of 2,000 square miles in area. A considerable portion of this area is hilly, the rocks, so far as they are known, belonging to the metamorphic series; but since there is evidence that diamonds have been found in the Ebe river, it may be that an outlier of the Vindhyan series exists there. To the west and south of this highland tract there are Gondwana rocks, including the coal-measures of the extensive Raigarh and Hingir field; outliers of the Deccan trap occur to the north-east. The principal rivers of this tract are the Mand and Ebe, with numerous tributaries. As there is always water in the Ebe, it is possible that some system of hydraulic mining might be applicable. Be that as it may, there cannot but be gold-bearing reefs from which all this gold has been derived.

Udepur State: Rabkob, Lat. 25° 28′ 30″; Long. 83° 17′ (A. S., 105 S.W.)—Rabkob is the chief town of the State of Udepur. Some of the early accounts of the washings and the assays of gold from them do not very clearly distinguish between those of Rabkob and Jashpur, which are separated from one another by about 40 miles.

Colonel Ouseley[1] was, it is believed, the first to call attention to these washings, which he did in a report to Government, dated 1847; there were then only three families of gold-washers at Rabkob, and at the localities mentioned below there were no resident washers, and the gold was said to be of inferior quality to that from Rabkob. It was sold at from Rs. 10 to Rs. 12 a tola. Although these workings are spoken of as mines, and went to considerable depths, as in Jashpur, they were not in the original matrix rock, but in detrital deposits from the metamorphic rocks. The first samples of dust yielded, on assay by Mr. Dodd, gold, 91·667; silver, 3·646; alloy, 4·687 = 100. Colonel Ouseley remarked

[1] Jour., As. Soc., Bengal, Vol. XXIII, p. 110.

that this dust had less the appearance of having been worn and flattened than had that usually washed from sands.

In 1849 Mr. Robinson took a lease of the village *with liberty to work the mines from Government*, and left a European agent to conduct operations, who, however, was afterwards compelled to leave in consequence of fever. Indeed, it may be added, the unhealthiness of this region must always prove a drawback to operations under European management. The gold obtained was sold for Rs. $14\frac{5}{8}$ per tola in the Calcutta bazaar, that being the value put upon it at the Mint. The result of Mr. Robinson's trial was that a man to whom he paid 1 anna could earn for him from 3 to 4 annas worth of gold.

In 1865 this locality was visited by the late Colonel Dalton,[1] Commissioner of the division, who has written that the production of gold was restricted by the number of washers, there being only six families of them.

These people were at work in pits similar to those in Jashpur. The produce of a day's washing for each *duin* or dish was only three grains, which led Colonel Dalton to suppose some deception had been practised, as the Raja of Sirguja, who contemplated making a monopoly of the industry, was with him. Judging from experience in Singhbhum, however, this amount was probably rather above than below the average earnings.

The other localities in Udepur mentioned by Colonel Ouseley as being gold-producing are—

KAMHAR,	on the Korija river,	Lat. 22°35′;	Long. 83°18′15″	A.S. 105, S.W.
BAIRAGI,	on the Sangul river	Lat. 22°42′15″;	Long. 83°21′30″	
SALKA,		Lat. 22°43′20″;	Long. 83°22′30″	
KHANDRAJAH,		Lat. 22°43′43″;	Long. 83°26′30″	
BAKARUMA,	on the Bharari river,	Lat. 22°31′45″;	Long. 83°29′	
JAMARGI,	on the Maini river,	Lat. 22°34′30″;	Long. 83°48′	

Central Provinces.—Auriferous sands occur in most parts of the Central Provinces, where there are exposures of the older crystalline rocks.

The census returns of 1872 give the total number of persons whose trade is gold-washing at 215. Out of the four divisions under which the districts are classified the Narbada Division alone returns no gold-washers. The other divisions contribute as follows: Nagpur, 139; Jabalpur, 52; Chatisgarh, 12. The Upper Godavari District, which is classed separately, and one of the districts included in the Jabalpur Division,

[1] Jour., As. Soc., Bengal, Vol. XXXIV, Part II, p. 22.

have no gold-washers, the latter being Mandla—a fact easily connected with its geology. The rocks are chiefly trappean, but it may be that even in this district towards the south, where traversed by the Bunjar river, gold-bearing sands occur, since samples of gold from the bed of that river are now in the Nagpur Museum[1], but whether obtained within the limits of Mandla or Balaghat is not stated. As regards the Upper Godavari District, gold-washing does take place there, wherever the washers come from.

Chatisgarh Division: Sambalpur District.—The census returns only give ten persons as being employed as professional gold-washers in Sambalpur. This is not improbably an under-estimate. In the chapter on Diamonds the persons who practise gold-washing in this district have been already described. The head-quarters of the principal colony are at Jhunan, on the Mahanadi, about 9 miles north-west of Sambalpur. Most of the early, already quoted, accounts of Sambalpur diamonds refer also to the fact of the Mahanadi and several of its tribuaries containing auriferous sands. Although the actual localities where gold-washing is carried on are numerous, it will be sufficient to relegate what has to be said on the subject under two localities where gold-washing was witnessed by the writer. These are Sambalpur town on the Mahanadi and the village of Tahud on the Ebe.

Sambalpur, Lat. 21° 28′; Long. 84° 2′.—Close to Sambalpur town the banks and bed of the river contain gold. In Colonel Ouseley's time it used to be found as far down as Sonpur.[2] The various tributaries of the Mahanadi which traverse the metamorphic rocks are all probably more or less gold-bearing.[3] The early writers did not recognise the probability of the gold and diamonds being derived from different sources. As both were found together in the bed of the Mahanadi, they were supposed to come from the same rocks. The diamonds have been shown on a previous page to be traceable back to the Lower Vindhyan rocks, while the gold, though possibly in part coming from the same, is chiefly derived from the metamorphics. At Jhunan, on the Mahanadi, there is a small colony of gold-washers, who travel to the different localities when the water falls after the rains.

Tahud.—Near Tahud, on the Ebe river, a party of the above washers were seen encamped and at work by the writer.[4] The spots where they

[1] Central Provinces Gazetteer, p. 26.
[2] Jour., As. Soc., Bengal, Vol. VIII, p. 1058.
[3] Records, G. S. I., Vol. X, p. 190.
[4] *Idem*, p. 191.

were then washing were within the area occupied by rocks of Talchir age, but whether the gold had been proximately derived from these, or had been brought down from the neighbouring metamorphic area, it was impossible to decide. There is of course no *primâ facia* improbability in these Talchir rocks containing gold; on the contrary, the boulder bed, containing as it does such a large proportion of materials directly derived from the metamorphic rocks, might naturally be expected to include gold. The occurrence of gold in the sandstones of the Talchir field has already been mentioned, and similar cases will be found in reference to still younger deposits on future pages. In Australia, a conglomerate bed of carboniferous age is known to be auriferous.[1]

Bilaspur District.—According to the census there are only two gold-washers in the Bilaspur District. The only recorded locality where gold is known to occur is in the Jonk or Jong river, near Sonakhan.

SONAKHAN, Lat. 21° 25′; Long. 82° 38′.—Whether this place owes its name to the fact of there having been a gold mine there is not known, but Captain Wilkinson [2] is our authority for saying that the Jonk river in this vicinity is auriferous. Although it is believed that Sonakhan itself is on the margin of the Lower Vindhyan rocks of the Chatisgarh basin, it is known that a considerable portion of the course of the Jonk south of Sonakhan is through metamorphic rocks. The sources of the river, however, are situated in the outlying tract of Lower Vindhyan rocks near Nowagarh.

Raipur District.—There were 12 gold-washers in Raipur in 1872. It is not known in what parts their operations are principally carried on. Captain Wilkinson states that gold is procurable in the Mahanadi at Rajoo.[2] The only place of similar name on the Mahanadi is Rajim.

RAJIM, Lat. 20° 58′; Long. 81° 56′.—Rajim is situated on Lower Vindhyan rocks. It is possible that the gold may have reached the Mahanadi by its tributary, the Pairi, which passes through metamorphic rocks 12 miles off in Nowagarh, though that would be rather far for it to travel.

Bhandara District.—In this district there are only three professional gold-washers. Gold-bearing sands occur in streams near Ambagarh and Thirora. The Son nala is mentioned also as gold-bearing, but as it does not appear on the maps it may be one of the above.

AMBAGARH, Lat. 21° 26′ 30″; Long. 79° 43′ 30″.—According to Mr. Wilkinson,[2] the Maroo stream, in Amborah pargana, used to produce gold. As there was formerly a pargana called Ambagarh, it is probable

[1] Geological Magazine, 1877, p. 286.
[2] Cal. Jour., Nat. Hist., Vol. III, p. 292.

that that was the place. The position given above is that of the town of Ambagarh.

THIRORA, Lat. 21° 24′ 30″; Long. 79° 59′.—An unnamed tributary of the Wainganga, near Thirora,[1] is said to contain auriferous sands.

In the Central Provinces Gazetteer it is stated that the gold of the Bhandara District is somewhat impure, only bringing from Rs. 10 to Rs. 12 per tola. Mercury is employed in separating the particles from the sand. The geology of Bhandara has not yet been fully ascertained, but the older metamorphic rocks are known to occur there as also some sandstones, &c., of Lower Vindhyan age.

Chanda District.—According to the census of 1872 there are only six professional gold-washers in this district. The search for gold is carried on, it is believed, in the eastern parts of the area, where metamorphic rocks prevail, but there are no published details as to the actual streams in which it is found.

Balaghat District.—The census return of 1872 gives the number of gold-washers living in the Balaghat district as being one only, but as gold is known to be washed in several places it is probable that either the gold-washers of Nagpur, who are returned as numbering 103, annually migrate into Balaghat, or the actual washers have some other trade under which they have been classed. The auriferous streams of this district are situated in the Lanji and Dhansua parganas.[2] The rocks belong to the older metamorphic series.

LANJI, Lat. 21° 30′; Long. 80° 36′.—This is the position of the town of Lanji, but it is in two of the principal rivers of the pargana of the same name, namely, the Son and Deo, that the auriferous sands occur. As being gold-producing, these, especially the first (which probably owes its name to the fact), have long been known.

Captain Jenkins,[3] Mr. Wilkinson,[4] and the Rev. Messrs. Hislop and Hunter,[5] all allude to the gold sands near Lanji. And it is probably in consequence of the mention of it in the paper by the last-mentioned authorities that this locality has received more notice in European works than many others in India. As stated above, there are gold-bearing sands also in some parts of the Bunjar river.

PANCHERA, Lat. 21° 55′; Long. 80° 16′.—According to the Central Provinces Gazetteer, gold is obtained in the Sonabera stream, near the Panchera ghât, in the Dhansua pargana.

[1] Central Provinces Administration Report, 1861-62, p. 124.
[2] Central Provinces Gazetteer.
[3] As. Res., Vol. XVIII, p. 213.
[4] Cal. Jour., Nat. Hist., Vol. III, p. 292.
[5] Quar. Jour., Geol. Soc., Vol. XI, p. 380.

MAU, Lat. 22° 13′; Long. 80° 10′.—From the above quoted authority, too, we learn that gold is found in the Nahr river, in the neighbourhood of Mau.

Jabalpur District.—In this district there were 14 professional gold-washers in 1872. Beyond this, and the fact that a sample of gold-dust said to be from Jabalpur was exhibited in the Indian Museum at South Kensington, there appears to be no record of the industry in this district.

Nagpur District.—The gold-washers of this district are more numerous than in any other one in the Central Provinces. They number 103. It is probable that they carry on their operations chiefly in the adjoining districts, though some of them may find sufficient gold in the streams which traverse the metamorphic rocks of their own.

Wardha District.—In this district there are 26 gold-washers, but there is no information available as to the precise localities where their operations are carried on.

Sagar and Damoh Districts.—In Sagar and Damoh there are 19 and 7 gold-washers respectively, but it is not on record that gold is found in either district.

Seoni District.—Within the limits of this district the sands of the Parqudhur stream produce gold. It rises in the Konye hills and falls into the Wainganga. The washers, of whom there are 12, consider it unlucky to earn more than 4 annas a day.[1]

Upper Godavari District.—Gold is said to be found[2] in two localities in the bed of the Godavari river within the limits of this district, namely, near Bhadrachellum and at Marigudem (Mariguram of map).

BHADRACHELLUM, Lat. 17° 40′ 30″; Long. 80° 51′ 45″.—Gold is washed for at the point where the Kinarsani river falls into the Godavari, on the Hyderabad side below Bhadrachellum. The rocks belong to the metamorphic or older crystalline series, but the Gondwana and Kadapah series are also represented close by. As already stated, diamonds are reported to have been formerly found here.

MARIGUDEM, Lat. 18° 17′; Long. 80° 36′ 30″.—Gold is washed for near the mouth of a small stream which, coming from the Nizam's territory, falls into the Godavari opposite Marigudem, in the Naggar taluk. It is washed by people called *Sonjharis* (*lit.* gold-seekers), not *Sonjerries* as the name is sometimes written, who come periodically for the purpose. They begin operations in August or September, or whenever the

[1] Balfour's Cyclopædia, &c.

[2] Central Provinces Gazetteer, p. 506.

river has fallen sufficiently to lay bare certain gravel banks in which the gold occurs in minute grains. The gold is of superior quality to that of some other localities, being valued at Rs. 16 a tola. The rocks of this neighbourhood are Gondwanas belonging to the Kamthi group, so this gold has possibly a doubly derivative origin.

Bastar.—The Bastar State, which is attached to the Upper Godavari District, does not return any gold-washers in the census tables, but gold-washing is nevertheless carried on there according to the Central Provinces Gazetteer close to Pratappur (? Partabpur of map), and at the junction of the Kutri (or Kuthari) and Indravati rivers, *i.e.*, near the village of Bharamgarh. The rocks of this portion of Bastar, it may be presumed, belong to the metamorphic series, but they have not as yet been examined by any geologist. The position of these two localities is as follows:—

PRATAPPUR OR PARTABPUR, Lat. 19° 59′ 30″; Long. 80° 47′ 30″.

BHARAMGURH, Lat. 19° 25′; Long. 80° 39′ 30″.

Rajputana.—Ajmir-Mhairwarra District.—According to Dr. Irvine,[1] gold-dust used to be found in the sands of the Luni and Khari rivers. The search, however, does not appear to be carried on at present. These rivers traverse rocks of the Arvali series and gneiss. The actual source of the gold is unknown. As rough indices of position, Raipur on the Luni, lat. 26° 3″, long. 74° 5′, and Sagramgarh on the Khari, lat. 25° 52′, long. 74° 29′ 30″ may be mentioned.

Gurgaon District.—But one locality, Sonah or Sohna, is known in this district where gold has been found.

SONAH, Lat. 28° 14′; Long. 77° 7′—It is possible that this place may owe its name to the fact of gold having been found there. When examining the schists of the Arvali series at Sonah, Mr. Hacket[2] was informed that small quantities of gold are found, after the rains, in the streams which take their rise in the hills close by.

Bombay.—Within the limits of the Bombay Presidency the districts of Dharwar, Belgaum, and Kaladgi in the Southern Mahratta Country, and the province of Kattywar, include all the localities wherein gold-bearing rocks are reported to exist.

Dharwar District.—In this district gold has been found at Chik Mulgund (Moolgoond), Surtur (Soortoor), Dambal or Damul, Dhoni, Hurti river near Guduk. All the available information regarding the auriferous tracts of Dharwar, Belgaum, and Kaladgi are contained in

[1] *Vide* Selections from Records, Government of India, Chap. XIX, p. 71.

[2] Records, G. S. I., Vol. XIII, p. 244.

papers by Captain Newbold,[1] Lieutenant Aytoun,[2] and Mr. R. B. Foote[3] of the Geological Survey. A letter by Mr. Scholt[4] to the *Times of India* also contains some information on the subject. Mr. Foote's paper, besides recording his own observations, gives a *résumé* of what was written by the other authorities. A map of the neighbourhood of Dambal is published with this paper.

Mr. Foote considers that the metamorphic rocks of the known gold-bearing area belong to three distinct groups or series, each characterised by certain lithological peculiarities. He distinguishes them by the following local names, namely, Dhoni, Kappatgode, and Surtur. The Dhoni group consists of a hematitic schist, accompanied by chloritic, hornblendic, and micaceous schists. It also includes several beds of white and grey limestone, which may prove a valuable source of lime. Above this group comes the one called Kappatgode, the members of which form the Kappatgode Hill. They consist likewise of hæmatitic schists with which are associated argillaceous schists, and the prevailing color has changed from green to reddish buff or mottled whitish. The third or Surtur group consists of hornblendic and chloritic schists, which are intimately associated with a massive diorite. Two other groups or series of granitic rocks in the neighbourhood, which do not appear to be auriferous, have had the names Guduck and Mulgund conferred upon them, from the names of the villages near which they are found.

Quartz reefs occur in all these series, but it is only in the streams arising from the Surtur series, according to the natives, that auriferous sands occur, and the richest of all, that called Surtur, lies entirely within the area occupied by the chloritic schists and diorite.

With few exceptions the quartz reefs in the Surtur series at their outcrops had been broken up by gold-seekers. Most of these reefs run parallel to the bedding, but in the other series they often occur cutting across the bedding.

In the Kappatgode series there is a reef called Hati Kati (Huttee Kuttee), in the debris from which, where it had been broken into by gold-seekers, Mr. Foote found a trace of visible gold. Pyrites altered into limonite and thin veins of chlorite occur in the quartz. Three rude sinkings and some shallow trenching indicate that mining by natives was carried on to some extent here. A shaft sunk on the east side of

[1] Madras Jour. of Lit. and Sci., Vol. XI, p. 44; and Jour., Roy. As. Soc., Vol. VII, p. 205; and Jour. As., Soc., Bengal, Vol. XIV, p. 291.

[2] Trans., Bombay Geog. Socy., Vol. XI, p. 1.

[3] Records, G. S. I., Vol. VIII, p. 133; and Mem., G. S. I., Vol, XII, p. 259.

[4] *Vide* Balfour's Cyclopædia, Art.—Gold.

the reef is supposed to have been the work of a Gold Company which was started during the Bombay share mania. A similar shaft near the village of Dhoni is known to have been the work of this Company. Australian nuggets are said to have done duty as samples of the results of these operations. The Hati Kati reef is 5 feet thick; it dips 40° to 50°, eastwards, and the strike is north by west to south by east.

Sulphides of the metals which commonly accompany gold were only found in the Hati Kati and two parallel reefs, but much of the quartz in the different reefs is what is called 'mouse-eaten' by Australian miners—an indication of the former presence of foreign minerals. Samples of quartz selected by Mr. Foote were assayed in the laboratories at the Mint and the Geological Survey, but did not prove to contain gold. Even were there evidence of the presence of a greater amount of gold, the inaccessibility of this locality and the scarcity of fuel and water are serious drawbacks. There are only two or three families of gold-washers or Jalgars in the neighbourhood. They use a sort of box made of light planks which is 3 to 4 feet long, 20 inches wide, and 9 inches deep, for the first and rough part of the washings. This box or trough corresponds to the Australian cradle. The sand is then removed to a dish or tray in which it is panned off. The iron sand with gold is further washed in a half cocoanut shell and the final residue treated with mercury. Mr. Scholt (*l. c.*) speaks in high terms of the care taken by these men, which he says surpasses that of the Chinese in Australia; but Mr. Foote considers the process wasteful, particularly in consequence of the shortness of the washing-box. The earnings of these men during the season varies from Rs. 5 to Rs. 50.

Mr. Scholt formed a very unfavorable, but apparently perfectly just, opinion as to the value of the alluvial deposits. The supply is very scanty, the stratum not exceeding 5 inches in depth, the bed rock being apparent everywhere. Twelve days' work at Surtur yielded him only from Rs. 2 to Rs. 3 worth of gold.

Lieutenant Aytoun, however, states that near Dumbal he sunk a shaft in the alluvium to a depth of 7 feet and found gold at all depths; and a Mr. Le Souef, who had had Australian experience, also states that he obtained gold from shafts. He took a more favorable view of the place than Mr. Scholt, but his statements are somewhat vague.[1]

In Captain Newbold's time the outturn from the Hurti, Surtur, and Dhoni streams was estimated at 200 ounces per annum, but either in consequence of the yield of gold having diminished, or other more lucrative employment having become available to the Jalgars, their numbers

[1] *Vide* his letter in Balfour's Cyclopædia, Art.—Gold.

have much decreased, and the outturn is probably not now one-tenth of what it was. Captain Newbold (*l. c.*) mentions that the Jalgars understand the ancient Hindu method of purifying the gold and improving its touch. The following shows the position of the above-mentioned localities in Dharwar, and also that of another, Chik Mulgund, in the Kor or Kod taluk, where gold used to be found according to Captain Newbold:—

SURTUR OR SOORTOOR, Lat. 15° 14′ 30″; Long. 75° 43′.

DHONI, Lat. 15° 17′ 30″; Long. 75° 47′.

DAMBAL OR DUMUL, Lat. 15° 17′ 30″; Long. 75° 50′.

HARTI OR HURTEE, Lat. 15° 20′; Long. 75° 35′ 30″.

CHIK MULGUND (or Moolgoond), Lat. 14° 35′; Long. 75° 27′.

Belgaum District.—Gold-dust within the limits of this district is reported to have been found in small quantities at or near the villages of Belowuddi, Byl Hongul, and Murgur.

The rocks are chloritic schists and diorites, with thin veins and nests of quartz, reefs being rare or concealed, if present, by surface soil.

BELOWUDDI, Lat. 15° 42′ 30″; Long. 74° 59′.—Lieutenant Aytoun obtained gold in the streams near this place, but it appears to occur in very small quantity. Mr. Foote failed to find any trace of gold there, and he was told that the Jalgars had not been there for ten years, so that it is evident they do not think much of its capabilities. The gold is supposed to have been derived from a quartz reef traversing the chloritic schists and diorite.

BYL HONGUL, Lat. 15° 50′; Long. 74° 59′.—At Byl Hongul, or rather near two small villages, Chikop and Murkombi of map, a few miles to the north, Mr. Aytoun obtained gold by washing, and the stream between these places was one ordinarily visited by the Jalgars; but Mr. Foote was informed by the local officials that gold was unknown there. He mentions finding one quartz reef in which there were no sulphides or other likely indications of the presence of gold.

MURGUR, Lat. 15° 53′; Long. 75°.—Mr. Foote was told by a native official that near the above village from Rs. 150 to 200 worth was obtained by the Jalgars, who in this case are Mohamedans; probably they are converts like the *Naths*. The rocks which are believed to contain the gold are said to be probably the same as those at Kappatgode. Gold is reported to occur also in the streams near Sogul, 4 miles south-east of Murgur.

Kaladgi District.—GULUDEGUD, Lat. 16° 3′; Long. 75° 52′.—Mr. Foote mentions a report, the accuracy of which he has reason to doubt, of auriferous sands being found in the streams there.

Kattywar.—Gold-dust in small quantities is said to be found in the Sourekha[1] (*Soowurn seekta*, Sans.; *lit.* gold-dust), a river which rises in the Girnar hills, but which is not marked on the maps. The Girnar hills rise to a height of 2,666 feet, and are said to be formed of granite with quartz veins. It seems to be doubtful, however, whether there are any old crystalline rocks in these hills. So far as is known, the rocks are volcanic of the Deccan trap period. Captain McMurdo is said to have stated that gold was also found in the river Aji, which passes Rajkot.

Afghanistan.—Gold-dust is reported to occur in the sands of many rivers in Afghanistan, but definite information on the subject is somewhat scanty. The geology of Northern Afghanistan is not very well known, and it is therefore impossible to say from what rocks this gold may have been derived. The gold near Kandahar occurs in connection with trap, which traverses cretaceous rocks, and it may be that the matrix of the gold in Northern Afghanistan is of the same age. At the same time older rocks are believed to occur in the Hindu Kush, and it may exist in some of them.

According to Captain Hutton[2] gold which is called *pillah* used to be imported into Kabul from Bokhara, where it was found in the river Amur, and the best qualities were sold at the rate of Co.'s Rs. 17 to 18 per tola; an inferior quality sold for Rs. 10 per tola.

The occurrence of gold is recorded in Kandahar, in the Hazara country, in the neighbourhood of Bamian, in Koh-i-daman, Kohistan, and Lughman.

Hazara Country.—Captain Drummond[3] states that gold is reported to be found in the streams which rise in the Koh-i-baba range, and Captain Hutton that it is reported to occur *in situ* in the rocks of some of the mountains; but he suggests that the supposed gold is possibly only either iron or copper pyrites, as samples of these, supposed to be gold, were often brought to him.

Kandahar, Lat. 31° 35′; Long. 65° 35′.—Gold is mined for in quartz veins 3 miles to the north of Kandahar city. These quartz veins, according to Mr. Griesbach,[4] occur on the lines of junction between hippuritic limestone and extensive outbursts of trap; the actual contact rock is partly calcareous, and it contains traces of copper and nickel. The gold is sometimes chiselled out in pure granules and sometimes in large nuggets; the stone is not taken out unless it contains visible gold.

[1] Selections from Records, Bombay Government, Vol. XXXVIII, p. 36.
[2] Cal. Jour., Nat. Hist., Vol. VI, p. 599.
[3] Jour., As. Soc., Bengal, Vol. X, p. 89.
[4] Mem., G. S. I., Vol. XVIII, p. 56.

It is carried to the city for treatment. The mine belonged to the Government, had been worked anyhow for some 12 years, and in 1872 was leased to a contractor for Rs. 5,000 a year; as much more was spent on working it, blasting with gunpowder being employed, and the yearly outturn was said to exceed Rs. 10,000. Subsequently, the mine fell in, and some of the miners who were working at the time below were buried. Mr. Griesbach considers that it is highly probable that gold will be found where the trappoid beds, which he describes, are altered by younger traps and traversed by quartz reefs. The disturbed state of the country prevented the Wali from acting on his advice and sinking new shafts.

It may be of interest to add here that there is an old record[1] of the discovery of a mine of gold in Seistan, which is thus described:—

"In the first month of the reign of Mahmud of Ghazni a vein of gold resembling a tree, of three cubits in depth, was discovered in a mine in Seistan, which yielded pure gold till the reign of Musaud, when it was destroyed and lost by an earthquake."

BAMIAN, Lat. 34° 52′ 30″; Long. 67° 45′ 30″.—Dr. Balfour states that gold is found, together with lapis lazuli, at Haladat, near Bamian; but there may be some mistake about the latter as this is not one of the recognised localities where it occurs, but gold may very possibly be found there brought by streams from the northern flanks of the Koh-i-baba.

ISTALIF, Lat. 34° 52′ 50″; Long. 69°.—Dr. Balfour states that gold is found at this locality, which is in the district of Koh-i-daman. It is also found in the sands of the Kabul river. The streams in Kohistan and above Lughman and Kuner, which rise on the flanks of the Hindu Kush, also contain gold according to Captain Drummond.

Punjab.—It has been not unfrequently stated that all the rivers of the Punjab, the Ravi alone excepted, contain auriferous sands. Probably there are some others which might be excluded from so general a statement; but the fact remains that the rivers and streams of the province, whether rising in the distant ranges of crystalline rocks forming the axis of the Himalayas, or merely having their sources in the outer and lower ranges of hills formed of detrital tertiary formations, do as a general rule contain gold. In the latter cases the gold must have a doubly derivative origin, and no veins, or other original deposits of it, can be expected to occur.

The practice of gold-washing in the Punjab is probably of considerable antiquity; formerly it afforded a source of revenue, and under the Sikh Government the tax amounted to one-fourth of the gross produce. As in

[1] Brigg's Mahomedan Power in India, Vol. I, p. 33.

most other parts of India, the possible revenue from this source has dwindled down to very small proportions, or has become wholly extinct; in the year 1860-61 it was Rs. 444, and in 1861-62 it was Rs. 530. The fact of gold being obtained by washing in the rivers of Subah Lahore is mentioned in the "Ain-i-Akbari."[1] The chronicler, or rather his translator, includes brass in the list of metals which were thus obtained!

The following account contains the most important authentic information on the subject of Punjab gold, the districts in which it is found being Bannu, Peshawur, Hazara, Rawalpindi, Jhilam, Amballa, and certain Native States.

Bannu (Bunnoo) District: KALABAGH.—At Kalabagh[2] and other points on the Indus below it, gold-dust is washed for, the annual value of the produce being estimated at Rs. 200. Whether this gold is derived from the tertiary rocks, as is that which is obtained in the streams and rivers from the Salt-range in the Jhilam district, or has come from the older rocks higher up the valley, may be an open question.

Peshawur District.—In the Indus above Attock[3] and in the Kabul river gold-dust occurs, though not in great abundance. There are about 150 men who wash during the cold and hot seasons; for the rest of the year they follow their regular avocation as boatmen. They often receive advances from those who purchase the gold, which is valued at Rs. 15 a tola. Each man obtains on an average 2 to 2½ tolas of gold, which from the time spent in its collection would yield a daily wage of about two annas.

Hazara District.—The bed of the Indus in this district also yields gold-dust, the quality and therefore the value of which is the same as of that obtained within the limits of the Peshawur district. The most prolific portion of the Indus is said to be that which traverses Dardistan.

Rawalpindi District: ATTOCK, Lat. 33° 52′ 30″; Long. 72° 15′ 30.″ The sands of the Indus at Attock are also washed for gold. Dr. Jameson[4] in 1843 stated that about 300 individuals used then to engage annually in the search for gold between Attock and Kalabagh. The washing was effected with the aid of a large wooden trough. Mercury was used and the gold obtained was sold for Rs. 16 per tola, one-fourth of which was claimed by the Sikh Government. The actual earnings of the men were estimated to be from 3 to 4 annas a day.

[1] Gladwin's Edition, Vol. II, p. 109.
[2] Jolem, p. 13; Mem., G. S. I., Vol. XVII, p. 95.
[3] *Idem*, p. 13.
[4] Jour., As. Soc., Bengal, Vol. XII, p. 221.

Jhilam District.—The gold-washings of the Salt-range are nearly all included in the Jhilam District.[1] They are situated in the beds of streams and rivers which take their rise in the sandstones of tertiary age, the gold apparently coming from beds of the lower Siwalik group. It has thus a doubly derivative origin, as in these beds it is, like the rest of the materials of which they are formed, merely detrital matter from the old crystalline rocks of the Himalayas. Much of the gold is invisible or nearly so, and would be lost but for the employment of mercury. In the year 1850 158 cradles were worked, and the tax upon these amounted to Rs. 525.

In 1848 Dr. Fleming was informed, according to Mr. Baden-Powell, that the production of gold was as follows :—

1844 .	409 tolas.
1845 .	272 „
1846 .	332 „
	1,013 tolas × 16 = say £1,620-16-0.

The Bunhar river, near the eastern end of the hills, is specially mentioned by Mr. Wynne as producing gold, and from it, westwards up to the Indus, many of the streams which rise on the northern flanks of the range contain gold.

Kangra District.—In this district gold is found in the Bias river near Haripur, and also in Spiti, Kulu, and Lahul.

HARIPUR.—In a paper by Captain Abbott[2] the process of gold-washing in the Bias river is described and illustrated. The gold occurs apparently in still finer particles than elsewhere, being literally dust. It is impossible to say what may be the proximate derivation of this gold as the river traverses both tertiary and old crystalline rocks. Since gold occurs at Shamsi[3] higher up the valley in Kulu, it originally probably all came from that neighbourhood. Traces of gold occur in the argentiferous galenas of Kulu,[4] and the sands of several streams in the same district are believed to be auriferous. Gold is obtained in the larger rivers of Lahul and Zangskar, but the outturn is small; it is mostly taken to Hindustan. In Kunawar, according to Gerrard, small quantities of gold are

[1] Fleming, Dr. Jour., As. Soc., Bengal, Vol. XXII, p. 543. Selections from Public Correspondence, Punjab Government, No. XXIII, p. 343; Baden-Powell. Punjab Products, p. 13. Wynne, A. B. Mem., G. S. I., Vol. XIV, p. 303.

[2] Jour., As. Soc., Bengal, Vol. XVI, p. 266.

[3] Kulu, &c., by Calvert, J, p. 21.

[4] *Idem*, p. 73.

found in the streams. The position of Kunawar is in the valley of the Sutlej to the north of Bisahir (or Bashahr) on the frontiers of Chines Tartary. Granite and other crystalline rocks are found there, and from these, or rather from the quartz veins which traverse them, the gold has probably been derived.

Amballa District.—KARRAR.—Specimens of gold from the Markunda river near this locality were exhibited at the Lahore exhibition. In Dr. Balfour's Cyclopædia it is stated that gold has been found in large quantities between Amballa and Kalka, but the original authority for the statement is not mentioned.

GUMTA, Lat. 30° 34′ 30″; Long. 77° 13′ 75″.—Gold-washing, as carried on in the year 1835 in the river Gumti, which was so called after two villages bearing that name, and situated on its banks, was described by Lieutenant Cautley.[1] From the description given, though it does not exactly coincide with the relative positions of the places mentioned, it would seem that Gumta of the modern maps, which is to the west of Nahan, was the locality referred to. The Gumta or Gumti stream is parallel to the Markunda. The washers, of whom there were only a few, carried on their operations with a large trough and sieve as elsewhere, and employed mercury for the final process. The gold was said to be very fine.

A royalty of one masha, Rs. 192, was levied by the Raja of Nahan. The daily earnings from one trough worked by two men varied from annas 2 to Rs. 2. A hope was expressed that the gold would prove as abundant as the Siwalik fossils, which about that time were first discovered.

Patiala State.—In the Native State of Patiala gold is washed for by the Sonjbirs in the bed of a small mountain stream according to Dr. Balfour.

Kashmir.—Though there is reason to believe that gold-dust used to be sought for in parts of Kashmir proper, there seem to be few notices regarding it. The "Ain-i-Akbari" says that gold used to be found in a river called Padmatti and at Puckely and Gulkut (? Gilgit), which came from the country of the Dards.

The principal localities where gold-washing is carried on in the territories of the Raja of Kashmir are apparently situated in Ladak.

KARGIL, Lat. 34° 34′; Long. 76° 10′ 30″.—Dr. Bellew[2] mentions having seen an old deserted mine in auriferous sands here, which had been

[1] Jour., As. Soc., Bengal, Vol. IV, p. 279.

[2] Kashmir and Kashgar, p. 103.

given up in consequence of some of the men having been killed by a portion of it falling in.

Ladak.—According to General Cunningham[1] gold-washing in the beds of the Indus and Shayok was carried on only by Mahomedans from Balti, as the Buddhists of Ladak had long been prohibited from the search. The reason was supposed to be to prevent them from neglecting their fields.

Kio, Lat. 34°; Long. 77° 18′.—One actual locality where gold-washing is practised has recently been visited by Mr. Lydekker;[2] it is at Kio, on the Markha river, where operations were being vigorously carried on. The gold is believed to be derived from certain veins of yellow quartz which are very abundant in the carboniferous limestones of that neighbourhood. In Ladak a common form of pickaxe used by the miners consists of the horn of the wild sheep (*Ovis vignei*) tipped with iron; this is mounted on a wooden handle and is said to be an efficient implement; this fact will be referred to again when speaking of Thibet.

A remarkable method of obtaining gold in Kashmir, which was formerly, if it be not still practised, was to peg down the skins of animals with the hair on them in the beds of gold-bearing streams. The hair acted as does the blanket used by the civilised miner, and arrested small particles of gold which are obtained when the skins are dried and shaken. This, according to the "Ain-i-Akbari,"[3] was the practice at a place called Puckely. The use of skins in this way was at one time[4] suggested as offering an explanation of part of the fable of the gold-digging ants, the true explanation of which is given below. It is stated that the custom of using skins for this purpose was formerly in vogue in Savoy.

Thibet.—Thibet is included in this account, as there is every reason for believing that for very many centuries a regular supply of gold has entered India from thence, and continues to do so to the present day.

Of the very highest interest are the accounts of the Thibetan gold mines, which are given by the Pundits attached to the Indian Survey for the purpose of exploring countries north of the Himalayas. Unwittingly these admirable native servants of the Government of India have furnished facts which have enabled Sir Henry Rawlinson, and independently Professor Frederic Schiern, Professor of History at the University of Copenhagen, to clear up a mystery which has been a puzzle to the historians and philosophers of many countries for upwards of 2,000 years.[5]

[1] Ladak, &c., p. 232.

[2] Records, G. S. I., Vol. XIII, p. 49.

[3] *Vide* Gladwin's edition, Vol. II, p. 136.

[4] Count Von Veltheim, 'Sammlung einiger Aufsatze,' Vol. II, p. 268; and Jour. As. Soc., Bengal, Vol. III, p. 207.

[5] *Vide* 'Ladak' by General Cunningham, p. 232.

A translation of Professor Schiern's paper,[1] by Anna M. H. Childers, will be found in the "Indian Antiquary."[2] It is a most remarkable example of learned research, and one very difficult to give in abstract. It is entitled "The Tradition of the Gold-digging Ants." But perhaps before giving the conclusions which Sir Henry Rawlinson and Professor Schiern have arrived at, it will be best in this place to briefly describe the Pundits' observations:—

"During the expedition of 1867 the Pundit who had been at Lassa fell in at Thok Jalung, an important gold-field in the province of Nari Khorsam, with a large encampment of Thibetan miners, and took the opportunity to gain information relative to the working of the mines. In the third expedition, in 1868, another Pundit passed on as far as Rudok, at the north-west extremity of Chinese Thibet on the frontier of Ladak, and on his way back from Rudok visited the gold-fields of Thok Nianmo, Thok Sarlung,[3] and Thok Jarlung. The map which accompanies Major Montgomery's narrative of the journeys of the Pundits gives in addition the gold-fields of Thok Munnak, Thok Ragyok, Thok Ragung, and Thok Dalung." . . . . "The miners' camp at Thok Jarlung, according to the measurements of the Pundits, is 16,300 feet above the sea level.

"The cold is intense, and the miners in winter are thickly clad with furs.

"The miners do not merely remain underground when at work, but their small black tents, which are made of a felt-like material, manufactured from the hair of the Yak, are set in a series of pits, with steps leading down to them . . . seven or eight feet below the surface of the ground." . . . "Spite of the cold the diggers prefer working in winter; and the number of their tents, which in summer amounts to 300, rises to nearly 600 in winter. They prefer the winter as the frozen soil then stands well, and is not likely to trouble them much by falling in."

They are occasionally attacked by bands of robbers who carry off their gold.

[1] Verhand, Kgl. Danischen Gesellsch. der Wissensch. for 1870. Printed separately in Danish, German, and French.

[2] Vol. IV, p. 225.

[3] Thok Sarlung had at one time been the chief gold-field of the district, "but had in a great measure been abandoned on the discovery of the Thok Jarlung gold-field. The Pundit passed a great excavation some 30 to 40 feet deep, 200 feet in width, and two miles in length, from which the gold had been extracted."—"Jour., As. Soc., Bengal," Vol. XXXIX, Pt. 2, p. 53, 1870.

Sir Henry Rawlinson's remarks on these reports of the Pundits' researches and travels are as follows[1] :—

"Now, then, for the first time, we have an explanation of the circumstances under which so large a quantity of gold is, as is well known to be the case, exported to the west from Khoten, and finds its way into India from Thibet; and it is probable that the search for gold in this region has been going on from a very remote antiquity, since no one can read the ex-Pundit's account of Thibetan miners 'living in tents some seven or eight feet below the surface of the ground, and collecting the excavated earth in heaps previous to washing the gold out of the soil,' without being reminded of the description which Herodotus gives of the 'ants in the lands of the Indians bordering on Kaspatyrus (or Kashmir) which made their dwellings underground, and threw up sand heaps as they burrowed, the sand which they threw up being full of gold."

Professor Schiern points out that the tradition was mentioned in writings of the middle ages, and those by Arabian authors. It survived among the Turks. Strabo and Albertus Magnus treated the whole story as a fiction. Xivrey supposed that the animals had become extinct owing to the *auri sacra fames.* Major Rennell supposed that the dwellers in mounds were *termites* or white ants. Humboldt's observations in Mexico on the habit of certain ants to carry about shining particles of hyalith was quoted by those who believed that the animals were really ants. Other authorities suggested that they were marmots, jackals, foxes, or hyænas. Pliny having stated that horns of the Indian ant were preserved in the temple of Hercules at Erythræ, Samuel Wähl, who maintained the hyæna theory, proved equal to the difficulty by suggesting that the horns might have been a *lusus naturæ.* Professor Schiern ingeniously argues that the horns had been taken from the skins of animals which formed the garments of the miners. It seems possible, however, that they were samples of the pickaxes made of sheeps' horns, which, as is mentioned above, are used to the present day by the miners in Ladak.

Professor Schiern further points out that ancient writers say that the ants worked chiefly in winter, and connects this with the statement of the Pundit above quoted.

In conclusion he writes:—

"For us the story partakes no longer of the marvellous. The gold-digging ants were originally neither real ants, as the ancients supposed, nor, as many eminent men of learning have supposed, larger animals

[1] *Pall Mall Gazette*, March 16, 1869, quoted in "Indian Antiquary," Vol. IV, p. 225.

mistaken for ants on account of their subterranean habits, but men of flesh and blood, and these men Thibetan miners, whose mode of life and dress were in the remotest antiquity exactly what they are at the present day."

It would be easy to write further upon the subject of Thibet gold; there being a surprising amount of information regarding it, as may be gathered from the references which are quoted at the end of this volume; but this could only be done by the not altogether legitimate sacrifice of a considerable amount of space, Thibet not being within our limits.

North-west Provinces.—Gold-bearing sands occur in some of the rivers of Kumaun and Garhwal, and, as in the case of the Punjab, in some of those which take their rise in the outer ranges of hills formed of tertiary rocks. Several of the rivers in the Moradabad district used formerly to be washed, as is described below, if they be not still. The earnings of the washers, as stated to Captain Herbert, did not exceed 2 annas per man, but he thought this an under-estimate. Other authorities put them at from 3 to 4 annas. The industry was a source of revenue to the Gurkha Government, but when the country became British territory the smallness of the sum caused it to be remitted by the Commissioner, Mr. Traill. In the Moradabad district in 1833, according to Mr. Ravenshaw, the gold-washers or Nariyas of Kot Kadir paid Rs. 50 a month, and those at Barapura Rs. 30, to the zemindar. On the washers in the Dhela river a tax of Rs. 2-8 was levied for each washing trough (called locally *katouti*), which was paid to the Government.

The use of mercury was known to these washers as it was in the Punjab. The undermentioned are the principal authorities on the gold of the North-West Provinces.[1]

District of Garhwal: ALAKANANDA RIVER.—This river and its tributary, the Pindar, contain auriferous sands. Moorcroft[2] describes the process of washing as it was carried on in the year 1819, and Captain Herbert[3] states that he obtained a speck of gold in granite at Kedernath, near one of the sources of the Alakananda. The whole courses of these two rivers are situated within the limits of the crystalline rocks, which fact serves to distinguish them from those about to be mentioned. The Ganges, where it traverses the outer zone of tertiary rocks in taluka Chandi, also contains gold, which is possibly locally derived, though some of it may come from the higher ranges, as no doubt all did originally.

[1] Herbert, Captain. As. Res., Vol. XVIII, p. 236. Ravenshaw, E. J. Jour., As. Soc., Bengal, Vol. II, p. 265. Medlicott, H. B. Mem., G. S. I., Vol. III, p. 179. Balfour, Dr. Cyclopædia. Atkinson, E. T. Economic Geol. of Hills of N. W. P., Pamphlet.

[2] Travels, Vol. I, p. 7.

[3] As. Res., Vol. XVIII, p. 236.

Beniganga and Sona.—Both these rivers have short courses in the outer hills till they join the Ramgunga in the Patli Dhun. The gold found in them is probably all doubly derivative.

Moradabad District: Ramgunga River.—In a paper by Mr. E. T. Ravenshaw, dated 1833,[1] an account is given of the gold found in the tributaries of the Ramgunga along the northern frontiers of the Moradabad district. The river in which gold-dust is most abundant is the Koh, which flows a few miles to the east of Naginah and falls into the Ramgunga, 4 or 5 miles below Sheakdi (?Sheikdih). Four parties of gold-washers, locally called Nariyas, used to carry on their operations at Kot Kadir, 12 miles from Kotdwar, whence the Koh issues from the hills, at Barapura, at Lakher ghât on the Ramgunga, and at Amangarh on the Phikanadi, a tributary of the Ramgunga.

In the Dhela, between Sheonathpur and the hills, 10 miles further east, gold was sought for in the rains by Nariyas, who lived at Kheloroli, 7 miles north of Kasipur. The gold from this river was said to be of better quality than that from any of the others. No gold was known to exist in the rivers further east in this district, and its presence in the rivers of the Bareilly district had not been ascertained.

Nepal, Darjiling, and Sikkim.—Although gold is not known to be washed for in Nepal, Sikkim, or Darjiling, there is reason for believing that it exists in these areas under similar conditions to those prevailing in the North-Western Himalayas.

In an account of the mineral productions of Nepal by Mr. B. Hodgson[2] gold is not mentioned, and in a description of the process of refining gold in Nepal, Dr. Campbell[3] states that the gold which is subjected to this process is imported from Thibet to the value of two lakhs per annum. The fact that there is no published record of the occurrence of gold in Nepal is doubtless due to the notoriously scanty information which we possess regarding the minerals of that country. Mineral productions are precisely what Native Governments are most particular to conceal; but we are not left to hypothesis alone for arriving at the conclusion that gold does exist, since, in one of the British districts at the foot of the hills, it is actually washed for, and though, politically speaking, it may be incorrect, yet from the geological point of view it will be most convenient to describe this source of gold here.

Champaran District.—A number of rivers and streams which take their rise in the outer ranges of tertiary (Sivalik) rocks on the borders of the Champaran district and Nepal are known to be auriferous, and gold-

[1] Jour., As. Soc., Bengal, Vol II, p. 265.
[2] Selections from Records, Bengal Government, No. XXVII, p. 63.
[3] Jour., As. Soc., Bengal, Vol. III, p. 622.

washing takes place annually, at the commencement and termination of the rains, in the Pachnad, Hurha, Balwi or Dhar, Achni and Kapan rivers.

In the Statistical Account of Bengal,[1] from which this information is derived, the opinion of a Revenue Surveyor is quoted without a suggestion of dissent to the effect that since the streams rise in these outer hills, the drainage of Nepal being cut off by a high range, and since the former have a rugged and precipitous aspect, therefore veins of gold might be found which would amply recoup the Government for any outlay it might incur in working them. That *veins* of gold occur in these rocks is, however, most improbable. The gold included in them is almost certain to be of detrital origin, and, like the materials generally of which the beds are formed, it was brought down from the higher ranges of crystalline rocks inside, which, therefore, contain the veins or other original matrix. The gold-washers of Champaran belong to a race called Tharu, and are, it is said, evidently of Mongolian origin, having similar features to those of the Mechs and Kacharis of Assam and the Bhutan Duars. Their earnings, it is believed, vary from 4 annas to a rupee, which gives a higher average than in almost any other part of India; it is possibly an over-estimate.

On the other hand, the gold must be of very inferior quality, if it be true, as is stated, that it only fetches Rs. 12, or three-fourths of the ordinary price, per tola. Nuggets of gold are said to occur there sometimes in stones which bear the imprint of fossil shells. It is probable that this supposed form of the gold is only iron pyrites. During the time the revenue survey was in progress, the amount of gold collected was very much less than it had been formerly, when, according to report, the Raja of Ramnagar collected several thousands of rupees' worth annually.

In a somewhat speculative paper published in 1848, Dr. Irvine[2] starts the hypothesis from *a priori* considerations, that gold and the ores of other metals probably occur in the rocks forming the hills near or rather above Darjiling; that such is the case has been proved with reference to the latter, and the discovery of traces of gold-dust in the streams would only be the fulfilment of a most reasonable anticipation.

Assam.—Assam has long been famous for the production of gold, and not a few authorities have stated that all its rivers contain gold-bearing sands,—some, however, limiting this general statement to those which rise on the hills on the north. Shorn of all exaggeration it would seem that there are few, if any, named rivers or streams in the districts of Darrang, Sibsagar, and Lakhimpur which do not yield gold, while in

[1] Vol. XIII, p. 228.

[2] Jour., As. Soc., Bengal, Vol. XVII, p. 137.

eight other districts included in the Chief Commissionership of Assam, namely, Goalpara, Kamrup, Nowgong; Garo, Jaintia and Naga Hills; Sylhet and Cachar, there is no gold, so far as our sources of information go. That it is wholly absent in all is not likely, but it is not and does not appear ever to have been sought for successfully in any of them.

The most interesting early account of the production of gold in Upper Assam is by a Hindu named Muniram, the Revenue Serishtadar of Bar Bandari,[1] whose paper on the subject Captain Jenkins forwarded in the year 1838 to the Coal Committee. In it we are told that before the British took possession of the country the *Sonwals* paid a yearly tribute of 4,000 tolas of gold, or in value, at Rs. 16 a tola, Rs. 64,000. While the Government had possession of Upper Assam 400 Sonwals paid a tax, and at the time of writing (*i.e.* 1838) the Raja levied a tax on 150 or 160 *jotes* (*i.e.* parties of four invividuals) of these Sonwal paiks. Colonel Hannay[2] estimates that in the northern district of Sadiya alone, including Lukhimpur, there were 10,000 of these Sonwals who had to pay at least 4 annas weight, or Rs. 4 worth of gold each; the total amount would be Rs. 40,000, and since much was probably paid by the Sonwals south of the Brahmaputra the total revenue may have been from £8,000 to £10,000, and the total outturn did not greatly exceed this, since gold-washing was a service performed by those who held land for their subsistence.

There appears to be no foundation whatever for the statement, first made apparently by Jacob,[3] that the yield of gold in Assam amounted to 30,000 ounces. Recently, in a lecture delivered to the Society of Arts by Dr. Hyde Clarke,[4] it was stated that the yield had formerly been 40,000 ounces, *i.e.* the equivalent of £140,000 at the very least. It can only be suggested that the rupees of the above statement have been mistaken by some one for ounces, and thus in all probability the error arose.

Muniram states that besides the abovementioned tax the Sonwals of Upper Assam, in the time of Raja Rajeswar Singh, used to present from 6,000 to 7,000 tolas of gold; besides which, gold was receivedfrom a number of places in Lower Assam and also from the Bhutias.

Four methods of collecting gold were practised according to Muniram:

1. The Kacharis or Cassaris wait for a rise in the river and immediately afterwards, on its fall, they scraped up the newly-deposited sand, which they washed for gold.

[1] Jour., As. Soc., Bengal, Vol. VII, p. 621.
[2] *Op. cit.*, Vol. XXII, p. 515.
[3] Precious Metals: Philadelphia, 1832.
[4] Jour., Socy. of Arts, Vol. XXIX, 1881, p. 244.

2. All other Sonwals wash for gold during the dry season.
3. The Rydegeea Phukun's Sonwals collect the leaves of the *copat* in the hills. These they burn and collect gold from the ashes.
4. The gold-washers in the Seedang (? Sitang) get the gold by washing the moss and slime which they scrape from the rocks in the bed of the river.

From the following detailed account, which appears to be worthy of reproduction, it will be seen that a statement quoted in Dr. Balfour's Cyclopædia, that no cradle is used in gold-washing in Assam, and that the sand is merely washed by passing water over it in any long leaf, is not well founded.

Some remarks seem called for to explain if possible the third method of obtaining gold which is mentioned by Muniram. That gold is ever taken up by plants and deposited in living vegetable tissue is not only improbable, but the fact that it is sometimes found among the roots of plants is considered to be attributable to the circumstance that it is a mineral not assimilated by plants, while the solutions in which it is carried into these positions are. Thus it is supposed that the solvents of gold being absorbed the metal itself accumulates by gradual increments. It seemed at first probable to the writer that the *copat* plant grew on the banks of the streams and acted mechanically by arresting small particles of gold. But on enquiry the *copat* would seem to be a common plant in Assam, which possibly belongs to the ginger family. Its leaves being thin but strong are commonly used to wrap up small parcels. Their connection with gold probably was that they were used to wrap up the gold, and the small three-cornered packets may have been burnt in order to save the fine gold adhering to the leaves, hence may have arisen the fable.

Colonel Hannay mentions that the soil found about the roots of trees, especially those of the tree fern, are rich in gold. This at once calls to mind the fact that skins of animals are laid down in gold-bearing streams in Kashmir, and horns of wild cattle, with the hair attached, in Burma for the purpose of arresting the spangles of gold. Indeed, the use of blankets in Californian and Australian quartz-crushing mills is due to an application of the same principle. The velvety surface of young sprouting ferns growing on the banks of streams might serve to arrest some gold, and these, if burnt as blankets are, would yield an auriferous ash.

Colonel Dalton mentions a tradition of a nugget having been found attached to an edible root. This of course may have been a chance occurrence, but on the other hand it may be explainable as above.

The following is Muniram's account of the method of washing and collecting gold from sand:—

"Wherever the current is strong with a falling bank above it, ending in a sharp turn of the river, the Sonwals examine the opposite shore where the sand from the falling bank is thrown, and if this should contain gravel mixed with the sand it is accounted a good place to find gold in.

"Each party consists of a headman (*patoee*) and four assistants (*pallees*), who wash in one trough (or *dorongee*); when they find a proper place to commence operations they begin by working about in the sand with a sharp-pointed bamboo (or *sokalee*), to find the depth at which the gravelly sand is; they then take it up in a piece of split bamboo (*bans chola*) and examine whether there is any gold-dust in it; if they see 12 or 14 bits they immediately build their houses and commence operations. They first bund up the deep part of the stream, if it be a small one, with sand, and if large with stakes and grass: the stream then takes a different direction over the sand; they allow it to wash away the upper surface of sand so as to expose the gold sand, when the bund is re-opened and the stream returns to its original bed. The upper sand is then scraped off and the gold sand collected with a kind of wooden spade (*kater dohtal*); this shovel is 1½ cubits long by 1 cubit in breadth, with a handle 4 cubits long; the blade is of the form of a crescent with holes at each corner, through which a string is passed and two men lay hold of and pull this string, while a third person keeps pressing the spade down in a perpendicular position; the sand is then taken up in small baskets with handles (*cookees*) and thrown on a bamboo lattice-work or strainer (*ban*) which is laid over the trough. This trough is made of wood and is three cubits long, one cubit broad, and one span high all round, with a slit three fingers wide at one end. Water is now thrown over the sand with a calabash having a large piece scooped out at the bottom, beside a very small hole on one side (*lao*); the water is thrown on with one hand, while the other hand is employed in moving the sand about and sweeping off the larger particles of gravel from the surface of the strainer; in this way the sand is spread on and water poured over it; and as the trough fills, the water and dirty sand runs off through the slit in it, while the clean sand and gold remain at the bottom of the trough. I forgot to say that the trough is placed at a small angle to assist the water and dirt to run off quickly. When 40 or 50 baskets of sand have been thus washed into the trough the Sonwals call it a *shia*, and if a *rati* of gold is produced from one *shia* they think themselves very fortunate indeed, for during the long days they

get about 30 *shias* or washings producing one *rati* each, and during the short days about 25 *shias*, each party thus making on an average about one-fourth of a tola of gold daily. When they happen to fall on a good old stream that has not been disturbed for five or six years, they get two *ratis* of gold from every *skia* or washing, and then each party makes about half a tola daily.

"The gold and sand of the last washing is collected into pottles (or *chonga*) by spreading a leaf of copat or some other plant at the end of the trough, and dropping water very gently on the sand through the small hole in the calabash, which causes a parting of the sand and gold thrown on the leaf; when the whole is collected in this way it is put into the pottle and tied up and the next washing is commenced on. As soon as they have collected enough in the pottles they give up washing the common sand, but pour out the gold and sand from pottles into the trough again, and putting in about an anna's weight of quicksilver for each tola of gold-dust, they pour water over the sand to keep it in motion, while the quicksilver remains below with the gold-dust and forms it into a lump; this lump is then put into a shell and on a fire of *nahar* wood charcoal; when the quicksilver evaporates the shell becomes lime, it is then carefully taken up in a spoon and thrown into water when the gold falls to the bottom; if it be of a brass color it is wrapped in a paste made of clay from the cooking *chulas* mixed with a little salt and burnt in a fire, which gives it a proper colour. This process causes an absolute refinement of the surface of the gold; it is the same used in gold refining by the natives generally, but in the latter case the metal has to be reduced in the first instance to very thin leaves to allow the muriatic acid fumes to penetrate and unite with the alloy."

A very large proportion of the gold which is obtained in Assam is doubly derivative coming from the degradation of the tertiary rocks. In the upper reaches of the Brahmaputra it is probably directly derived from the crystalline rocks. It is important that this should be clearly understood, and that the prospect of finding gold in its original matrix in the easily accessible parts of the valley of the Bhramaputra is very small.

Darrang District.—In the Darrang district several of the rivers which join the Bhramaputra on the north are said to contain gold, which is still or has formerly been washed for. They are the Bhoroli, which is perhaps identical with the Bhairavi, the Burigang (or Boongawn), and the Bargang (or Burrowgawn).

Bhoroli River.—This name appears to be repeated in several parts of Assam, so it is uncertain which is referred to. A particular river

which bears it, however, is said to have been noted for its gold.[1] It joins the Bhramaputra 5 or 6 miles above Tezpur.

BHAIRAVI RIVER.—Under this name a river in Darrang is stated[2] to yield gold of a superior quality. The name does not appear on the map, but from the indication of its position as rising in the Aka hills it is probably the proper name of the Bhoroli.

BURIGANG RIVER.—This river rises in the Dufla hills and joins the Bhramaputra near Bishnath; it is said to contain gold.[3]

BARGANG RIVER.—This river rises also in the Dufla hills and joins the Bhramaputra 3 or 4 miles above the last mentioned. Both for the quantity and quality of its gold it is said[4] to have been more noted than the Dikrang even.

Sibsagar District.—The principal rivers whose sands include gold in the Sibsagar district are the Dhaneswari, with its tributary the Pakerguri, the Desue or Disoi, the Jangi or Janji, and the Buri Dihing; but the auriferous deposits on the flanks of the Naga hills extend throughout from the Dhaneswari[5] to the Noa Dihing.

DHANESWARI (OR DHUNSIRI) RIVER.—For comparison with the yields of other rivers, Colonel Hannay mentions that he was informed by the chief of the washers that in this river 15 men obtained 7½ tolas of gold in from 12 to 15 days.[6]

DISOI (OR DESUE) RIVER.—In Colonel Hannay's time the gold-washers carried on their operations one and a half days' journey above Jorhat, where the bed is stony. Here the yield was about the same as in the Dhaneswari, 15 men having obtained 7½ tolas in 12 days.[7]

PAKERGURI RIVER.—According to Colonel Hannay,[8] Mr. Montgomery Martin has recorded that the Assam Government received into the royal treasury 1,500 grains weight of gold yearly from a gold mine called Pakerguri, situated at the junction of the Dhaneswari with the Bhramaputra. There is some obscurity about this, as the Pakerguri joins the Dhaneswari a day's journey from the Bhramaputra.

The Disoi and the Joglo rivers yielded the best gold in Assam, and the gold ornaments for the Raja's family are said to have been made exclusively from the gold obtained in them.

[1] Jour., As. Soc., Bengal, Vol. VII, p. 126.
[2] Statistical Account of Assam, Vol. I, p. 106.
[3] Eastern India, by Montgomery Martin, Vol. III, p. 648.
[4] *Idem.*
[5] Jour., As. Soc., Bengal, Vol. XXII, p. 513.
[6] *Op. cit.*, Vol. VI, p 628.
[7] *Op. cit.*, Vol. VII, p. 628.
[8] *Op. cit.*, Vol. XXII, p. 513.

Jangi or Janji River.—In this river according to Colonel Hannay,[1] 15 men washed for twelve days and obtained 7½ tolas of gold.

Bari Dihing River.—Colonel Hannay mentions[2] that a party of traders in salt, 24 in number, washed for gold for one month in this river and realised only 12 annas weight, or about 12 rupees' worth.

Lakhimpur District.—This district appears to include a greater number of named and distinctly auriferous rivers and streams than the whole of the rest of Assam put together. The total yield of gold about 1853 was, according to Colonel Dalton, twenty pounds weight per annum, worth, say, about £1,200. Here too the Bhramaputra, or as it is called above Debong Mukh the Lohit, contains gold in sufficient abundance to be washed for. The principal tributaries of the Bhramaputra on the north which yield gold are the Dikrang, Borpani, Subanshiri, Sisi, Dihong, Dibong, Digara, and on the south the Joglo and the Noa Dihing.

Bhramaputra River.—Colonel Hannay states[3] that about the year 1838, above Sadiya, a party of gold-washers, consisting of 12 men, washed for 20 days and realised seven tolas of gold. In the vicinity of Tengapani Mukh a party of Kacharis, 60 in number, washed for five days and realised 25 rupees' weight of gold; also 35 men for one month, who collected half a tola or 8 rupees' worth of gold each.

In the year 1853[4] the total outturn of the Bhramaputra was said to be from one pound to a pound and a half weight of gold per annum.

In the year 1855 Colonels Dalton and Hannay were requested by Govbrnment to make a further and more complete examination of the auriferous deposits of Upper Assam than they had previously done. They first commenced operations a few miles above the Bhramakhund gorge; but finding the deposits less rich as they penetrated further into the hills they returned to Parghat, 8 miles below Bhramakhund.

Here the river debouches from the mountains after cutting through an enormous deposit of earth and boulders to the depth of 150 feet.

The gold obtained above Parghat contained a certain proportion of dendritic and crystalline particles, while below that point it consisted of flattened spangles (*pepites*), evidently the result of attrition.

The actual source of the gold was not ascertained. At Bhramakhund there are slates and felsites *in situ*. Travelled boulders of granite, gneiss, &c., were observed there, as also much white, ferruginous, and cellular quartz. The latter was possibly the matrix of the gold.

[1] Jour., As. Soc., Bengal, Vol. VII, p. 628.

[2] *Idem*, p. 627.

[3] *Idem*, pp. 627, 628.

[4] *Op. cit.*, Vol. XXII, p. 514.

Gold from the Bhramaputra forwarded by Colonels Dalton and Hannay, which was assayed by Dr. T. Boycott at the Calcutta Mint, yielded only 88·281 per cent. of pure gold.[1] This confirms an opinion of Muniram that the gold obtained from the Kacharis was of an inferior character because they always obtained it in the Bhramaputra.

This gold was obtained partly in a Californian cradle worked by four men at Gurumora, 18 miles below Bhramakhund. Two and a half tons of stuff which were passed through it yielded 30 grains, or in value Rs. 2-8. In the native trough (or *duruni*), worked by three men, the yield from 18 cwt. of stuff washed in one day was about 12 grains, or in value 1 rupee. The natives looked upon this as a poor yield, stating that after a flood they sometimes got double that amount.

Dikrang River.—This river has a long course and enters Lakhimpur from the Dufla hills if it does not rise in them. It was formerly noted[3] for the quality and quantity of the gold found in its sands.

Borpani.—This river is said to be a tributary of the Pisola, a name not on the map. There is, however, a Borpani, a tributary of the Dikrang. It is said[4] to have been more remarkable for the quantity than the quality of its gold.

Subanshiri River.—There is little recorded about this river, but the average yield about the year 1853 was from three to four pounds weight of gold. It was thus one of the most valuable.[5]

Sissi River.—Colonel Dalton[6] estimates the average yield from the gold-bearing sands of this river to be 15 grains to a ton. About one pound weight of gold was obtained per annum from this stream.

Dihong River.—The gold from this river contained 90·234 per cent. of pure gold. It is alluded to as being one of the richest in Assam. In the experiments conducted by Colonels Dalton and Hannay[7] $5\frac{5}{7}$ tons of gravel yielded 90 grains of gold, or at the rate of $16\frac{1}{8}$ grains per ton. If the large fragments which can be removed by hand be excluded the yield would be 22 grains per ton.

The Californian cradle used on this occasion was found to give proportionally more to each of the four men employed upon it than did either the native trough with its three men, or the Singpho washing-dish with two. The annual yield was from two to four pounds

[1] Mem., G. S. I., Vol. I, p. 93.
[2] Jour., As. Soc., Bengal, Vol. VII, p. 622.
[3] Eastern India by Montgomery Martin, Vol. III, p. 646.
[4] *Idem.*
[5] Jour., As. Soc., Bengal, Vol. XXII, p. 514.
[6] *Idem.*
[7] Mem. G. S. I., Vol. I, p. 92.

of pure gold apparently, but the name is printed Dibong (*vide infra*, Dibong).

Dibong River.—The annual yield of gold from this river was estimated in 1853 to be from one pound to one and a half pounds in weight; another statement is that it is from two to four pounds. In one of these cases it is evident that Dibong is a misprint for Dihong.[1]

Digaro River.—About 5 miles from its junction with the Bhramaputra, gold was found by Colonels Dalton and Hannay in the bed of this river, but only in small quantities, and higher up stream washing was not successful.[2]

Joglo or Jugla River.—This river rises in a range of small hills which stretch across from Jaipur to Sadiya. After a very short course of a few miles it falls into the Buri Dihing.

In the Joglo the soil and sand is scraped from the banks and washed; that which has collected about the roots of trees, especially about those of tree ferns, is considered to be most rich in gold.[3] Allusion has been already made to this above, and also to the tradition that in this tract a native traveller found gold in lumps attached to an edible root. In olden times it is said that from the richness of the gold here the area through which the river flows was kept as a royal preserve, and Muniram says that the gold brought by the Sonwals of this tract was the best in all Assam. In the year 1853 it was visited by Colonel Dalton,[4] who states that it had been deserted by the gold-washers in consequence of it costing more to propitiate the evil spirits of the place who guarded over the mineral treasures than they could afford to pay. As the spirits were not considered to be hostile to Europeans, Colonel Dalton, without any preliminary propitiation, set the washers who were with him to work. The ancient alluvial deposit here appears to be of very considerable extent and thickness. A stratum of gravel, about 15 feet above the highest water-mark, was proved to contain gold. The natives made use of a sluice by forming two embankments with bamboo and rubbish, thus dividing the river into three channels, which enabled them to turn the water in or out of the central channel into which they collected a heap of gravel. By means of sieves they removed the larger pebbles, while the current carried away the finer sediment. The residue was then washed in pans with much more satisfactory results than usual.

[1] Jour., As. Soc., Bengal, Vol. XXII, p. 514.
[2] Mem., G. S. I., Vol. I, p. 91.
[3] Jour., As. Soc., Bengal, Vol. VII, p.
[4] *Op. cit.*, Vol. XXII, p. 511.

Colonel Dalton's rough estimate of the outturn was 18 grains of gold to the ton of rubble which was washed. This was equal to about 8 grains per man per diem. He points out that before the yield of this field can be properly ascertained the base of the deposit should be examined.

Noa Dihing.—According to Colonel Hannay[1] a party of 20 Kacharis who washed in this river for three months, towards the end of 1837, obtained 10 tolas weight of gold, which was sold at Sadiya at the rate of Rs. 12 per tola. Their earnings, therefore, were Rs. 2 per man per month. Colonel Hannay remarks on the fact that after the coarser portions are removed the residue includes a number of minute and beautiful crystals of quartz. This has not been noticed elsewhere in Upper Assam.[2]

During the examination made by Colonels Dalton and Hannay in 1855,[3] the Noa Dihing was found to contain gold in larger proportions than the Bhramaputra, but only in the form of minute spangles, very liable to be carried away in the washing. The gold was found to diminish in quantity as the hills were neared. Traces of platinum were obtained with the gold.

Khasi Hills.—There is a sample of gold in the geological museum which is said to have been obtained in the Khasi hills, and Dr. Oldham obtained traces of gold in the iron sand from these hills.

Manipur State.—For an account of the production of gold in Manipur we must go back to a letter by Captain Grant to Mr. Swinton, dated April 1832.[4] The principal interest in this letter centres in the description of the method of washing. The sand and gravel is first placed in a sieve and the finer parts fall on to a hollowed plank, 4 feet long and 2½ feet wide at the upper end and 1½ feet at the lower, which is open, the top and margins being protected by a rim or margin half an inch high. The lower half is cut into grooves half an inch deep and the same in width. The fine sand caught in these grooves is washed in a wooden dish resembling a shield in shape, which has a polished black internal surface and a receptacle in the centre; placed floating in the water it is revolved till all the sendiment is removed and the iron sand and gold left remaining. The river in which the gold occurs is called the Ningthee. By means of the above described implements about 1 grain of gold was obtained in a quarter of an hour.

[1] Jour., As. Soc., Bengal, Vol. VII, p. 627.
[2] *Conf.* Gold Fields of Victoria by R. Brough Smyth, p. 260*n*.
[3] Mem., G. S. I., Vol. I, p. 91.
[4] Jour., As. Soc., Bengal, Vol. I, p. 148.

Tipperah.—The occurrence of gold in Tipperah is not indicated by any recent authority, but Tavernier,[1] in his enumeration of places where gold is produced in Asia, mentions the kingdom of Tipra, for which perhaps we should read Assam. He says the gold "is coarse, almost as bad as that of China."

British Burma.—Within the limits of British Burma gold has been found in the beds of the Irawadi and some of its tributaries, in the Pegu division, and in the beds of the Sittang and tributaries. The Tavoy river and the Great Tenasserim and tributaries in the Tenasserim division, also contain auriferous sands, but the gold-washers' trade appears to be very unremunerative. So far as is known no gold has been found in the Arakan Division.

Pegu Division: PROME, Lat. 18° 47′ 53″; Long. 95° 18′ 18″.—Mr. Theobald[2] states that gold was occasionally washed for in the sand of the Irawadi opposite Prome, but he himself only witnessed it at the following locality.

SHWE-GYENG, Lat. 19° 2′ N.; Long. 95° 5′ E.—Mr. Theobald spells the name of this place, which is in the Pegu division a little above Monyo, differently from that of another locality presently to be mentioned, which is in the Tenasserim division; but in the Gazette of British Burma they are both spelt as above. The word means gold-washing.

The gold is found in a coarse gravel, and the sand, after the removal of the coarser portions by a strainer, is washed on an inclined board. The heavy portion caught on the board is then finally washed in a circular hand-dish, and the gold is amalgamated with mercury. The earnings are said to be small, not more than two or three annas, a miserable remuneration where the ordinary hire for a cooly is eight annas.

Tenasserim Division.—SHWE-GYENG, Lat. 17° 54′ 40″ N.; Long. 96° 51′ 15″ E.—In the year 1853 Captain Wyndham visited the gold-washings which are situated near the junction of the Shwe-gyeng and Moot-ta-ma rivers, about 10 miles to the south-west of the town of Shwe-gyeng, on the Tsit-toung (Sittang). These washings are known to be of great antiquity, and in the time of the Native Government there was a Farmer General who paid a certain sum to the royal treasury and sublet the privilege of washing to numbers of persons.

Specimens of the gold-bearing sands which were obtained by Captain Wyndham were forwarded to Dr. Oldham[3] who reported upon them.

[1] Travels, Part II, Book II, p. 156.
[2] Mem., G. S. I., Vol. X, p. 343.
[3] *Op. cit.*, Vol. I, p. 94.

In a fifth of a cubic foot ·75 of a grain was obtained by washing and in addition ·20 by amalgamation, in all ·95 of a grain. The sand consisted of particles of metamorphic rocks with schorl and magnetic iron. Two nuggets purchased in the bazaar, and which may have come from the Shan States, were imbedded in quartz. The gold dust contained 92 per cent. of pure gold and 8 per cent. of silver.

Subsequently this locality was visited by Mr. Theobald,[1] who says that the auriferous beds presented much resemblance to those containing gold in Russia, and which had been described by Sir R. Murchison in his Siluria. From the marked scarcity of quartz pebbles he concluded that quartz was not the sole matrix; he believed that the gold was derived from the rocks near the sources of the Moot-ta-ma, and his estimate of the daily earnings of the washers was only 5 annas per man. Subsequently some Chinese tried washing here, but did not find the work sufficiently remunerative so they gave it up.[2]

In the year 1867 Mr. Abernethy,[3] an Australian miner, aided by the Government, penetrated further than the Chinese usually worked, but was unable to make the work pay. He condemned the sources of the gold as being steep and rocky, and having a hard smooth ledge upon which gold is seldom found in paying quantities.

He also examined the sources of the Baw-ga-ta with much the same result. None of the accounts quoted state whether there are any quartz reefs in this region or not.

Yay or Re, Lat. 15° 15′ N.; Long. 97° 53′ E.—According to the Rev. Mr. Mason, gold is found in the streams which fall from the granite ranges between Yay (Re) and Monmagon or Moung-ma-gan.

Henzai, Lat 14° 48′ N; Long 98° 10′ E.—The last-quoted authority states that gold was found by Mr. O'Riley with the tinstone at this locality.

Tavoy, Lat 14° 5′ N; Long 98° 10′ E.—Gold is also said to occur with the tin ores which are found east of Tavoy. The richest deposit is one of red earth and pebbles near the source of the Tavoy river. On the eastern side of the range, at the base of which this deposit rests, the Siamese Government, according to Dr. Morton, who is quoted by the Rev. Mr. Mason, employ several hundreds of men permanently to wash for gold; each man is expected to find one tickal's weight, or about 20 rupees' worth of gold per annum. In former times the Burmese Government exacted a similar service on the Tenasserim side.

[1] Report on Administration of British Burma, 1863-64, p. 56.

[2] *Op. cit.*, 1866-67, p. 96.

[3] *Op. cit.*, 1868-69, p. 107; and Gazette of British Burma, Vol. II, p. 649.

A native officer in Tavoy obtained about 10 rupees' worth of gold in nine days' washing. The composition of this gold, according to an assay at the Calcutta Mint, was—gold, 87·895; silver, 9·241; base metal, 2·864; total, 100.

TENASSERIM, Lat 18° 8′ N.; Long. 98° 55′ E.—According to Dr. Helfer[1] almost all the tributaries of the Tenasserim river contain gold. Near the old town of Tenasserim there are, or used to be, pits sunk in the alluvium from which gold was obtained. It is stated that the workers sometimes obtained one or two annas' weight during the season.

Upper Burma.—The use of gold in Burma, both for the purpose of ornamenting buildings and decorating the person, is universal throughout, but it is perhaps more prominently brought to notice in the cities and towns of Upper Burma. A portion of this gold is obtained from washings in the country, but by far the greatest amount is imported from China. Mr. Spears, as quoted by Dr. Oldham in 1855, estimated the average imports at 1,100 lbs. weight, and the indigenous gold which was brought to the capital at 360 lbs., making a total consumption of 1,460 lbs. Except when manufactured into leaf the export was prohibited.

It seems probable that the gold of Upper Burma is more frequently doubly derivative like the gold of Assam than is that of Lower Burma, which in some instances certainly comes directly from the crystalline rocks.

HUKONG VALLEY.—Captain Hannay[2] enumerates gold with other products of the Hukong valley. It is found both in dust and in pieces of the size of a large pea. The rivers which produce the greatest quantity are the Kapdup and Nam Kwan; pits are dug on the banks of the former, and the gold is found in the old alluvial deposits. In quoting the above account Dr. Anderson adds to it that he was told by a Kamthi Shan and the Chinese at Momein that gold is abundant near the supposed junction of the two main streams of the Irawadi, in the Kamthi country.

KANNEE MYO, Lat. 22° 30′; Long. 95°, on the Kyendwen River.—When describing the occurrence of platinum at this locality (*vide* p. 169), the mode of collecting the gold with which it occurs has already been mentioned. Horns of the wild cow, with the hair on, were planted in the beds of the river to arrest the gold, and when charged with the spangles were sold for 12 or 13 tickals each. The addition that deers' horns were sometimes used for the same purpose is a complete puzzle, as

[1] Second Report on the Provinces of Ye, Tavoy and Mergui; Calcutta: 1839, p. 34.
[2] Jour., As. Soc., Bengal, Vol. VI, p. 270.

the velvet on deers' horns could hardly act in this manner; the use of deers' skins would be intelligible enough.[1]

UPPER IRAWADI.—In the upper parts of the Irawadi both at Bhamo and near Thingadhaw, where the coal mines are, gold is obtained in the sands.[2] Near the coal mines of Ket-zu-bin, which are some miles about due south of those of Thingadhaw, Dr. Anderson[3] states there is a small rivulet which is auriferous; he was informed that a single washer could earn the eqivalent of 3 shillings a day. A few miles nearer Thingadhaw the Ponnah creek contains gold; but the washers are described as being miserably poor; they stated that much larger quantities were obtained at Shwe Gyeng two days' journey northwards. Dr. Anderson also records[4] that when at Bhamo he was shown a small quantity of gold in grains as large as peas, which he was told came from a hill to the north of the village of Ponline.

Silver: General Remarks.—Silver occurs native and alloyed with gold, but one of its most common modes of occurrence is in combination with sulphur as a sulphide, and when in this condition it is often associated with sulphides of other metals, such as lead, antimony, copper, arsenic, &c., &c. Its occurrence as a chloride appears to have been only once recorded in India.

Although there is abundant evidence to show that by metallurgical processes the natives of some parts of India were able to separate silver from gold, and also to extract the silver from argentiferous galena, there appears to be no very direct proof forthcoming that silver was ever produced to any large extent in the peninsula, though it is not improbable that such was the case. It may be a disputed point as to what countries were indicated by Pliny in the following passages in so far as they refer at least to silver: "The Dardaneans," he says, "inhabit a country the richest of all India in gold mines, and the Setæ have the most abundant mines of silver." Again: "In the country of the Nareæ, on the other side the mountain Capitalia (*i.e.* Mount Abu), there are a very great number of mines of gold and silver in which the Indians work very extensively." These passages have already been quoted in reference to gold. It has been suggested by Mr. Calvert that the country of the Setæ was the *Wazir-i-rupi*, or silver country of the Wazirs, *i.e.* Kulu, where argentiferous galenas undoubtedly do occur (*vide* Chapter VI).

[1] Jour., As. Soc., Bengal, Vol. I, p. 16, and Vol. III, p. 207.
[2] Oldham. Embassy to Ava, Appendix, p. 344.
[3] Expedition to Yunan *vid* Bhamo, p. 200.
[4] *Idem*, p. 69.

General Cunningham many years ago, however, expressed an opinion that the passage ending *Setæ vero argente* may have referred to the *Seths* or native bankers in whose hands the wealth of India has been for ages. But one of his reasons for doing so was that the existence of ores containing silver in India was not then generally recognised.

As for the silver mines in the country of the Nareæ, it may be that they were identical with some of the numerous ancient mines in Southern India, where we know that argentiferous galena was found (*vide* Chapter VI). These are situated in the districts of Kadapah and Karnul, and were therefore in the vicinity of, if not actually included in, the country of the Nairs or Malabar; the silver may have been brought to the ports of Malabar and there sold to Chinese and other traders. There seems to be good reason for believing that the Chinese did obtain silver from India; it was a metal more highly esteemed by them than gold, for which they were willing to exchange it, according to Tavernier,[1] at par! who says that except in Japan there were no silver mines in all Asia. However, in another place he mentions gold and silver mines in Assam (*op. cit.*, p. 187).

Marco Polo,[2] in his description of Malabar, states that ships coming from the East to trade there brought gold and silver, together with silks, spices, &c., to exchange for the products of the country, but in his time the local production may have ceased or the silver may have come from other countries to be reshipped to China, where there has been always too great a demand for it to make it likely that it was exported from thence.

It has been thought by some that names compounded of the word *Chand* or silver, which belong to certain towns and rivers in the Bhagulpur division of Bengal, may have reference to an early knowledge of the fact that the ores of lead which occur in their neighbourhoods were argentiferous.

The extraction of silver from argentiferous galena is probably still practised in Kandahar, and possibly also in Kashmir; but the only region where it seems to be a regular industry is in the Shan States. Dr. Balfour[3] states, however, that at Jungumrazpilly, in Kadapah, the natives extract silver from galena by a tedious, clumsy, and expensive process in which the lead is all lost. This may be a remnant of the former manufacture to which, as is suggested above, Pliny's allusion refers.

[1] Travels, English Edition, Part II, Book II, Chap. XXIII, p. 156.

[2] Colonel Yule's Marco Polo, Vol. I, p. 150.

[3] Cyclopædia, Art.—Galena.

Marco Polo[1] speaks of mines containing a great amount of silver ore in Badakshan, upon which Colonel Yule has remarked that he does not know of any nearer than those of Prayan, in the valley of Panjshir, south of the crest of the Hindu-kush.

In the table which follows there will be found enumerated all the well-authenticated assays for silver of the ores of lead and copper in India which have been proved to be argentiferous. A second table gives the percentages of silver which have been found alloyed with Indian gold from different localities. As the information available in reference to the abundance of the galena is given elsewhere, it will be unnecessary to anticipate it here.

There are, however, several recorded cases where native silver has been said to have been found, and to these reference must first be made.

Madras: MYSORE.—According to Sir W. Ainslie,[2] Captain Arthur discovered silver in its native state in thin plates adhering to some specimens of cubical crystals of gold. He is also said to have found it in the condition of chloride associated with iron pyrites. These statements, though scarcely of economic importance, have been so frequently quoted in works on Southern India that it has been thought well to reproduce them here. If the assays by Dr. Scott of the Karnul galena are to be depended on they indicate an extraordinarily rich ore: 374 oz., 175. oz. 3 dwts., 165·76 oz. of silver in the ton of lead; but in his original examination, according to Dr. Balfour, he found no trace of silver. If these amounts were really found by careful assay then the Karnul galena mines certainly deserved the title of silver mines.

Regarding some Kadapah galena from a mine, 8 miles north of Kadapah town, which had been worked by Tipu Sultan and abandoned as being unprofitable, Dr. Heyne[3] states that, on analysis by the Assay Master in Bengal, it was found to contain, according to a letter from Dr. Roxburgh, 11 per cent of silver, for which, probably, we should read eleven ounces to the ton: since 11 per cent otherwise stated means 246·4 Ibs to the ton—an incredible amount.

The average percentage of silver alloyed with the gold of the Wynaad has been stated to be about 15 per cent., but it is probably less.

Rajputana: **Ajmir District.**—A statement exists which may be taken for what it is worth, that silver was found in sand in a well

[1] Colonel Yule's Marco Polo, Vol. II, pp. 325 and 327*n*.
[2] Materia Medica of Hindustan: Madras, 1813, p. 58.
[3] Tracts, p. 316.

situated in the western portion of the city of Ajmir, called the Lakhan Koti, but the amount realised was insignificant.[1]

Bombay: Dharwar District.—In the streams from the Dambal or Kappatgode hills, native silver was found by Captain Newbold[2] in small quantities. It was associated with native copper in the gold-dust which was being washed for. A fragment of a grey ore of silver was also met with, and some white metallic particles, which it was thought might be silver. Some particles of native silver were subsequently found under similar circumstances by Mr. Foote.[3]

A rumour that silver occurs in the volcanic island of Adjar, off the Kattywar coast, to say the least, needs confirmation, of which at present there appears to be none.

The following account of the method of extracting silver from galena in the Shan States is given as being probably fairly representative of the native process generally.

Upper Burma: Shan States.—At Kyouktat, a large village, there are some smelting works for the argentiferous galena which occurs in the limestones of the district; the precise position of the mines could not be ascertained by Mr. Fedden,[4] who gives the following account of the process. The ore is put into a small cupola or blast furnace, together with charcoal and a proportion of broken slag. The cupolas are made of clay and are about 3 feet high and from 14 to 16 inches in diameter. The blast is produced by means of wooden cylinders with pistons, which are worked by two women who stand on a staging for the purpose.

As the galena is reduced by the sulphur being driven off, the metal accumulates at the bottom of the furnace, and it is then run out and cast into pigs, which on setting are removed to the refining shed, where they are placed in a reverberatory furnace, in which the fuel, consisting of large pieces of charcoal, is kept supported on fireclay supports just above the molten metal. The litharge formed on the surface is removed by means of an iron roller, and the process, which may last for twenty-four hours, is repeated till all the lead has been abstracted, apparently without the aid of cupellation, and the silver remains, in such a pure condition that until it has been alloyed by the silversmiths it is not used for currency and jewellery. The litharge is subsequently reduced in order to convert it back to metallic lead. The smelter at Kyouktat buys up all argenti-

[1] Selections from Records, Government of India, Vol. CXIX, p. 67.

[2] Madras Jour., Lit and Sci., Vol. XI, p. 43.

[3] Records, G. S. I., Vol. VII, p. 140.

[4] Salween Surveying Expedition: Selections from Records, Government of India, Vol. XLIX, p. 39.

ferous and cupriferous refuse from the silversmiths' shops and separates the metals in his furnaces.

Table of Assays showing the amount of silver per ton of lead [1] obtained from galena.

District.	Name of Mine.	Oz.	Dwts.	Grs.	Analyst.	Date.	Sample from whom received, or Reference.
					Madras.		
Kadapah	Jungumrazpilly	10	14	0	P. W. Wall	1858	P. W. Wall.
	Do.	13	13	0			
	Do.	5	14	12	A. Tween	July 1871	W. King.
	Do.	2	15	12			
	Do.	22	7	0	F. R. Mallet	May 1870	Do.
	Lunkamulla	9	2	0	P. W. Wall	1858	P. W. Wall, Madras Jour. of Lit. and Sci. Vol. XX, p. 284.
	Do.	8	4	0			
	Baswapur	8	4	0			
	Do.	35	7	0			
Karnul	Guzalpully	5	10	0	P. W. Wall	1858.	
	Koilkeutla	13	0	0	Do.	"	
	?	374	0	0	Dr. Scott	...	Dr. Balfour's Cyclopædia, Art.-Galena.
	?	175	3	0	Do.	...	
	?	165	15	0	Do.	Jany. 1859	Report to officer in charge of Govt. Central Museum.
					Bengal.		
Sontal Perg.	Bairuki †	29	8	0	Johnson and Mathey.	O tr. 1856	J. Barratt.
	Laksmipur near Nia Dumka	50	6	3	A. Tween	ec. 1860.	
Bhagalpur	?	52	8	14	F. R. Mallet	May 1871	Commissioner of Bhagalpur.
	? (Gangue)	3	18	9			
	Phaga ?	58	2	22	A. Tween	June 1875	C. H. Denham.
	Phaga †	65	1	0	C. Henwood	1879.	
	Do.	103	2	12	Chem. Exr. to Govt.	...	? 55 chittacks to the ton.
	Dudijor †	42	3	0	C. Henwood.		
	Kejarea	46	4	3	Do.		
Birbhum	?	5	7	19	A. Tween	1869.	
	?	21	14	11			
Manbhum	Dhadka	119	4	16	A. Tween	June 1870	V. Ball.
	Do.	99	0	0	F. R. Mallet	April 1881.	
Hazaribagh	Hisatu †	70	0	0	H. Piddington.		
	Do.	0	0	0	Do.		
	?	11	15	4	A. Tween	June 1870	J. Donaldson.
Sirguja	Bhelounda	Trace			Do.	1864	Col. Dalton.
Do. ?	Chiraikhund ?	7	7	0	Do.	June 1870	Dr. Stratton.

[1] In some cases the results are stated to be per ton of ore; these are distinguished in the table by a dagger thus † affixed.

Table of Assays showing the amount of silver per ton of lead [1] *obtained from galena.*—(contd.)

District.	Name of Mine.	Oz.	Dwts.	Grs.	Analyst.	Date.	Sample from whom received, or Reference.
Central Provinces.							
Sambalpur	Jhunan	12	5	0	A. Tween	Feb. 1875	V. Ball.
Raipur	Chicholi	9	19	6	Do.	May 1870	R. B. Smart.
Hosungabad	Joga	21	3	0	F. R. Mallet	June 1879	G. J. Nicholls.
	Sleemanabad	19	12	0	A. Tween	June 1870	T. W. H. Hughes.
Rewah and Bundelkhand.							
Rewah	Burgowa	8	6	14	A. Tween	June 1870	Dr. Stratton.
		5	4	12			
Jhansi		10	12	0	Do.	May 1873.	B. W. Colvin.
Rajputana.							
Meywar		10	12	9	A. Tween	Oct. 1873.	Pol. Ag., Meywar.
Bombay.							
Panch Mehals Gujarat	Jubhan	5	0	0			
Punjab.							
Hazara	Kakal Gashi, Habibulla	7	18	11	F. R. Mallet	Sept. 1877.	Financial Comr., Punjab.
Sirmur ?		13	10	0	A. Tween	Dec. 1865	J. Henfrey.
		26	15	0			
		24	10	0			
Simla	Subathu	10	12	12	Do.	1869	J. Schiller.
Kulu	Parbatti river	22	17	8	A. Tween	1869	F. Schiller.
	Do.	89	16	16			
	Do.	13	14	9	Do.	Mar. 1870.	F. Calvert.
	Do.	17	19	8			
	Do.	81	16	14	Do.	May 1870.	Do.
	Do.	38	19	6			
	Ballarag	65	6	16	Do.	Oct. 1873	A. G. Young.
	Koman Kot Kundi	25	6	8	Do.	Nov. 1873	J. Calvert.
	?	46	1	4	Do.	May 1874	Do.
	?	†50	12	16	Do.	June 1874	Do.
	?	18	1	14	Do.	Do.	A. O. Hume.
	?(No. 8 lode)	20	8	8	Do.	Do.	J. Calvert.
Lahul	Shigri	89	0	0	T. W. H. Hughes	Sept. 1874	Do.

[1] In some cases the results are stated to be per on of ore; these are distinguished in the table by a dagger thus † affixed.

Table of Assays showing the amount of silver per ton of lead[1] obtained from galena.—(contd.)

District.	Name of Mine.	Oz.	Dwts.	Grs.	Analyst.	Date.	Samples from whom received, or Reference.
North-West Provinces.							
Masuri . .	? ...	16	6	16	A. Tween . .	Feby. 1873..	Col. Need.
Nepal.							
Nepal . .	? ...	14	14	0	A. Tween . .	Jany. 1863..	Col. Lal Singh.
Burma.							
TONGHU . .	......	20	8	7	A. Tween . .	May 1871...	Capt. Cooke.
Do. . .	Between Phagat and the Yougaten ?	5	14	0	D. Waldie . .	1864 .	Letter from E. O'Riley, Esq., to Chief Commissioner.
	Do. .	9	0	0			
	Do. .	Trace.					
	Do. .	5	8	0			
AMHERST . .	Teetameelay Hill .	8	3	8	Do. . .	Mar. 1873 .	M. Fryar.
Do. . .	Teetalay Hill .	Trace.					
Do. . .	Meezine Hill .	14	14	6	Do. . .	Dec. 1872 .	Do.
MAULMAIN .	......	19	5	14	A. Tween . .	1864 .	Capt. Cooke.
TAVOY . .	......	16	7	9	Do. . . .	Sept. 1863 .	Asst. Secy., Govt. of India.
Do. . .	......	Trace.					
TENASSERIM .	?	4	14	7	Do. . .	July 1875 .	Col. Duncan, Secy. to Chief Comr.
	......	31	0	16	Do. . .		
?	?	12	17	8	Do. . . .	Oct. 1875 .	
MERGUI .	King Island . .	13	1	8	A. Tween . .	Mar. 1872 .	M. Fryar.
	Do.	11	8	16			
	Do.	11	0	0			
	? . .	12	5	0	Do. . . .	Mar. 1872 .	Messrs. Gillanders, Arbuthnot & Co.
BAMO . .	......	58	14	8	Do. . . .	June 1863 .	Dr. Williams.
YUNAN . .	Kyet You, three days' march to north of Momein	104	10	6	A. Tween . .	Mar. 1870 .	Dr. J. Anderson.
Do. . .	Ponsee Silver Mines, Khakhyeu Hills .	73	10	0			

[1] In some cases the results are stated to be per ton of ore; these are distinguished in the table by a dagger thus † affixed.

Argentiferous Copper Ores.

District.	Name of Mine.	Oz.	Dwts.	Grs.	Analyst.	Date.	Samples from whom received, or Reference.
Bengal.							
SONTAL PERGS.	Bairuki . .	52	5	0	Johnson & Mathey	Oct. 1856.	
Do. .	Do. (*Pacos*) .	85	0	0	H. Piddington .	...	Jour., As. Soc., Bengal, Vol. XXI, p. 74
SINGBHUM .	...	2	5	17†	Messrs. Philips & Darlington.		
		1	2	20†			
		0	19	14†			
Burma.							
...	Yoonzalin River .	31	6	12	D. Waldie . .	1870 .	Procdgs., As. Soc., Bengal, 1870, 279 (O'Rileyite).

Percentages of Silver alloyed with Indian Gold.

District.	Locality.	Gold.	Silver.	Analyst.	Date.	Reference.
Madras.						
Wynaad .	Alpha reef . .	67·07	32·93	A. Tween .	Dec. 1874.	W. King.
	Devala reef . .	93·	7·			
	Do. . . .	84·7	15·3	Do. . .	Sept. 1870.	J. W. Minchin.
	Monarch . .	82·69	11·32	Do. . .	Jan. 1875.	W. King.
	Do. . . .	87·96	12·04			
	Devala surface .	90·9	8·67			
	Devala reef . .	86·86	10·96			
	Averages .	84·74	14·03			
Kolar in Mysore.	......	91·66	15·3	Do. . .	Sept. 1875.	W. King.
Bengal.						
Jashpur .		94·64	5·15	A. Tween. ...	Dec. 1874.	Col. Dalton.

[1] In some cases the results are stated to be per ton of ore; these are distinguished in the table by a dagger thus † affixed.

CHAPTER. V.

COPPER.

Copper: General Remarks.—The copper ores of peninsular India occur both in the older crystalline or metamorphic rocks, and also in several of the groups of transition rocks, as, for example, in the Kadapah, Bijawar, and Arvali groups. In extra-peninsular India they are found for the most part in highly metamorphosed rocks, the precise age relations of which to those of the peninsula are not in all cases quite clearly made out as yet.

The ore of most common occurrence is the copper sulphide or pyrites, but towards the outcrops it is commonly altered into carbonates or oxides. The associated minerals are in general identical with those which are found under similar circumstances all the world over. Recent analyses by Mr. Mallet have tended to clear up much of the uncertainty which attached to two minerals which were found in Indian copper mines, and were supposed, by those who first examined and described them, to be worthy of specific distinction: these were called respectively mysorin and syepoorite.

As a rule, to which there are probably not very many exceptions, the copper ores of India do not occur in true lodes, but are either sparsely dissemminated or are locally concentrated in more or less extensive bunches and nests in the rocks which enclose them; occasionally cracks and fissures traversing these rocks have by infiltration become filled with ore which thus resemble true lodes.

In not a few of the cases about to be enumerated, it is believed that the ores exist only as the merest traces, but it is thought better to state here what is actually known regarding them rather than to pass them without notice. As will be seen from the following detailed descriptions, there are, both in the peninsular and extra-peninsular regions, mines

of great extent whose histories are lost in antiquity. At the present day the extraction and smelting of copper ores is only carried on in the most petty manner. In the majority of cases the miners are unable to cope with the water which floods their mines, and, in spite of the fact that their earnings are small, the copper which they turn out cannot be sold at a price which would enable it to compete at the regular markets on equal terms with metal imported from Europe.

Madras.—Traces of copper ores, in greater or less abundance, have been met with in the following districts of the Madras Presidency: Trichinopoli, Bellary, Kadapah, Karnul, and Nellore.

As will be seen from the following accounts, the ore appears to have been mined and worked at several of these localities to a considerable extent by the ancients, but the attempts which have been made to establish profitable mining by Europeans have not hitherto proved successful.

Trichinopoli District.—The gneiss in the neighbourhood of Olapaudy and Vapoor, in the north of Trichinopoli, is frequently stained with the copper carbonates, and south of the latter Mr. H. Blanford[1] found several pieces of cupriferous veinstone, but did not succeed in discovering any *in situ*. The specimens were considerably waterworn; they consisted of quartz with nests of malachite, red oxide, fahlerz, and native copper. There does not appear to be any record of ancient copper mines having been found in this district.

Kadapah District.—Traces of copper ores occur in the old lead mines at Jungumrazpilly, which are described in Chapter VI. According to Captain Newbold[2] and Mr. Foote,[3] faint indications of native copper impressions, supposed to be of crystals of copper pyrites and stains of the carbonates, appear to be the principal signs of its presence with the galena.

Karnul District.—In this district copper ores occur in the Goomanconda valley, in the hills east of Somadupilly and at Agriconda.

Goomanconda, Lat. 15° 32′; Long. 78° 14′ 30″.—Traces of copper ores occur among the quartz veins and trap which traverse the Kadapah rocks of the Calwa hills. At the western end of the largest of these, and immediately south of a hanging wall of quartzite to the west of Goomanconda, there is an old copper mine, upwards of 20 feet deep, which is hewn in solid rock, at various points along which there are trial pits. In the former the veinstone has been wholly worked out. Mr. Foote, who visited the locality, failed to elicit any information

[1] Mem., G. S. I., Vol. IV, p. 216; Trichinopoli Manual, p. 69.

[2] Jour., Roy. As. Soc., Vol. VII., p. 150.

[3] Mem., G. S. I., Vol. VIII, p. 269.

from the villagers as to the identity of the former miners. Only small traces of malachite, azurite, and purple copper were found.

SOMADUPILLY.—In the hills east of this village, which is stated to be to the west-south-west of the last-named locality, Mr. Foote[1] found traces of copper ores in a quartz vein, which runs from east-north-east to west-south-west. They consisted of specks of copper pyrites and tiny cavities with films and acicular crystals of malachite.

AGRICONDA OR AGNIGUNDALA, Lat. 16° 11′; Long. 79° 47′ 30″.—Dr. Heyne appears to have been the first to bring before the notice of the public the fact of the existence of copper ores and ancient mines at this locality, as he states that, in the year 1797, he laid a report of his discovery before the Government.[2]

Mr. Foote states that there were formerly extensive mining operations at this locality, and there are still many large pits to be seen. Traces of malachite and azurite form films on the surface of the joint planes on a hard, fine-grained whitish quartzite. The village of Guntapalem, which was the centre of operations, is now an abandoned ruin.

Bellary District.—Captain Newbold[3] states that there are ancient copper mines which were said to have been made under the direction of Hyder Ali, on the lower ridge of the copper mountain range, 5 or 6 miles west of Bellary cantonment. They were abandoned as unprofitable. The ore was the green carbonate which occurred in thin layers filling up seams in a slate associated with hornblendic and micaceous schists and gneiss. These excavations are not of great extent.

Nellore District.—The localities in this district where there are traces of copper ores, and where there have been mines, are numerous; but it is not easy to trace all of these on modern maps. The first writer upon the subject appears to have been Dr. Heyne,[4] who in the year 1800 visited the Venkatagiri and Kalastri zemindaris, which he says were situated between Nellore and Guntur, and with this statement commences a series of indications of position, which it is difficult to reconcile owing to these names being repeated in different taluks. On a modern map of the Nellore district one portion of Venkatagiri is at the extreme south, and Kalastri is still further south in the district of South Arcot; but the actual localities which Heyne mentions are all apparently situated in or near outlying portions of these zemindaris, either in the northern part of Nellore or in the districts adjoining it.

[1] Mem., G. S. I., Vol. VIII, p. 268.
[2] Jour., As. Soc., Bengal, Vol. IV, p. 575; Tracts, p. 108.
[3] Jour., Roy. As. Soc., Vol. VII, p. 150; Bellary Manual, p. 96.
[4] Tracts, p. 108; Jour., As. Soc., Bengal, Vol. IV, p. 574.

In a paper by Mr. James Prinsep[1] reference is made to the formation, in 1831, of the Indian Copper Mining Company in Madras, the object of which was to work these ores. A long quotation from a pamphlet by Dr. Heyne is made; this pamphlet was published in Madras about the beginning of the century. A description and analysis of ores received by the Asiatic Society is then given. The existence of huge ancient excavations and hills of copper slag proves the extent of the early workings, and the small proportion of copper found in the slag affords testimony to the skill of the early metallurgists. Captain Newbold[2] gives a detailed list of mines and accounts of the peculiarities of each under the following heads: Kunchgarlaconda, Salighiri, Nila, Gunni, Bungheralmetta, Cumbaldinny, Yerrapilly, and Adimutipuram. The ores are said to occur both in the mass of, and in fissures traversing, hornblendic and garnetiferous schists, with which intrusive sheets of trap are associated. As the principal mines were situated at or near the following villages, it will perhaps be sufficient to mention them.

Garimanipenta or Gunnipenta, Lat. 14° 59° 30′; Long. 79° 37′.—This village, and another called Yarapalli or Yerrapilly, 4 miles to the east of it, are in the centre of a district where there are mines of considerable antiquity. According to Captain Newbold,[3] the natives of the locality attribute the working of the earliest mines to the kings of Bijanagar. Afterwards, when the Hindu empire fell in the year 1564, it is believed that the Mogul conquerors and the agents of Tipu and Hyder successively carried on mining. The excavations are described as being of great magnitude and the extensive mounds of copper slag and scoriæ testify to the fact that the mines were not worked in vain.

A late explorer in this district states that the principal ancient native mines were not near this locality, but 30 miles further north, near Gorganpully, where there were mines 100 feet deep and several hundred feet long. Mines in the Venkatagiri taluk are said to have been worked by the Nawab of the Carnatic before the year 1780, but were given up on the assumption of the country by the British. The first attempt by Europeans to work the ores of these localities were made in the year 1803,[4] and from time to time others have been made. Thus, in or about the years 1831 to 1835, Mr. Kerr and others failed to work the mines with profit, and in 1840 the Brothers Ouchterlony expended a good deal of time and money in an endeavour to establish

[1] Jour., As. Soc., Bengal, Vol. IV, p. 574.
[2] Jour., Roy. As. Soc., Vol. VII, p. 150.
[3] *Op. cit.*, Vol. VII, p. 58.
[4] Nellore District Manual, p. 60.

a profitable system of mining with the aid of an experienced Cornish miner, but they appear to have also failed. In 1867, the renewal of an old lease to work copper mines in the Kadapah and Nellore districts was sought for by Mr. J. Campbell from the Madras Government, but was refused on its original lines. Quite recently there has been a project for working these ores again, and some excavations along the outcrops are stated to have produced a large quantity of ore.

The information as to the nature and extent of the deposits is far from complete, although much has been written on the subject. The evidence is conclusive that in certain places very rich ore was obtained, containing as much as 75 per cent. of metallic copper; in others it appears to have been much mixed up with iron and quartz, &c.

Mr. Lavelle, who recently extracted ore there, with a view to testing the extent of the lodes and for the purpose of obtaining samples to be forwarded to England for assay, obtained a considerable variety of ores. Specimens of these were forwarded to Mr. King,[1] who states that they included the following:—

A—*Chrysocolla* (in garnetiferous schists of which the garnets, though small, might from their colour and transparency be called precious garnets).

B—Copper glance (chalcocite), chrysocolla and malachite;

C—Chrysocolla, malachite and ferruginous red oxide (mysorin ?);

D—Copper pyrites, chrysocolla and malachite in limonite;

E—Copper glance with chrysocolla and malachite.

A very full account of these Nellore ores was published two years ago[2] by Mr. Mallet with special reference to the occurrence among them of mysorin and atacamite. He quotes the original description and analysis of mysorin by Dr. Thomson, which was made in 1814, and the subsequent references to it in mineralogical works, and also the analyses of these ores which were made by Mr. Prinsep. The conclusion he comes to from an analysis made by himself is that mysorin is simply an impure malachite, which owes its dark colour to admixture with ferric oxide and chalcocite. For further information regarding these mines reference should be made to the authorities quoted.

With regard to accessibility, we are told that Garimanipenta is within 9 miles of a public road, which leads to the canal at Kaveley, and the ore from Gorganpully could be taken to Ramaputnam, 20 miles distant. A cart carries forty maunds for 10 miles per rupee, and boats can be had to convey the ore at Rs. 2-8 per ton to Madras.

[1] Mem., G. S. I., Vol. XVI, p. 83.

[2] Records, G. S. I., Vol. XII, p. 171.

Mr. King, in reviewing the information which he has collected on the subject, is of opinion that to want of knowledge and other causes the early attempts to work these mines may be attributable, and not necessarily to a deficiency either in quantity or quality of the ore.

Hyderabad.—Dr. Walker[1] states that just below Yelgurrup, a village in the Ramghir Circar, there is an island which produces copper ore. A tradition exists that the ore was worked by Frenchmen in the service of a great talukdar named Zaffur-ood-dowlah. Dr. Voysey considered the ore to be poor and unproductive. The locality does not appear on modern maps. Mr. Vanstavern has communicated to the Geological Survey the discovery of native copper somewhere in this region, but he had not visited the actual spot himself.

NEELGOONDAH, Lat. 17° 3′; Long. 79° 18′.—Traces of the copper carbonates occur in the granites at Neelgoondah, according to Dr. Walker.

Bengal: Bhagulpur Division, Birbhum District: BODH BANDH, Lat. 24° 0′ 20″; Long. 86° 55′.—On Captain Sherwill's geological map of Bengal, as also on his ordinary survey maps, a locality is marked in the bed of the Adjai river, about three-fourths of a mile north-east of the village of Bodh Bandh, where copper pyrites was found. A note on the map states that the mine was *not* worked in 1850. A specimen of ore from this locality is enumerated in the MS. register of the old Economic Museum.

Deoghur District: BAIRUKI, Lat. 24° 35′ 30″; Long. 86° 40′ 15″.—The discovery of copper at this locality was made by a native in the year 1849, who brought specimens to Mr. Vincent, Deputy Magistrate of Deoghur. In January 1850 the spot was visited by Captain Sherwill,[2] who obtained samples on and at a short distance below, the surface, which afforded sufficient material for an extensive and practical assay of the ore by Mr. Piddington.[3] A letter published by Mr. Barratt[4] in 1856 describes the mining operations which were then going on. These accounts and some unpublished notes in the possession of the Geological Survey are the only sources of information regarding this deposit which are available at present.

The deserted excavations and rubbish heaps are situated close to the river, and within view of, being indeed only about 300 yards distant from, the chord line of the East Indian Railway, at a point about 5 miles

[1] Madras Jour. of Lit. and Sci., Vol. XVI, p. 183.

[2] Jour., As. Soc., Bengal, Vol. XX, p. 1; Friend of India, February 28th, 1850.

[3] *Idem*, p. 3; and Vol. XXI, p. 74.

[4] Addressed to Messrs. Mackey and Co., Calcutta, dated Birbhum Iron Works, December 1856, p. 7.

north of the Baijnath station. Captain Sherwill states that on removing the surface soil and digging to a depth of a couple of feet, he hit upon a rich though narrow vein of copper ore, yielding 30 per cent. of pure metal. He traced the ore for about 100 feet and found galena associated with the copper. Mr. Piddington's classified list of the specimens obtained at this locality is as follows. It shows that a considerable variety of valuable ores occur there.

1st Group. Variegated or Peacock copper of miners	Bright Peacock.	A.
	Dull Peacock.	B.
	Marbled Peacock with a pale greenish gossan.	C. contains silver, with a pale greenish gossan.
2nd Group. Grey coppers	Dull massive grey copper.	D. contains silver.
	Bright grey copper.	E.
3rd Group. Red ores *Pacos and Colarados* of Peru and Mexico	Bright red *Pacos.*	F. contains silver.
	Dull pale red to liver-coloured *Pacos.*	G. contains silver.
	Dark hard veins resembling tile ore with soft shining black specks and veins.	H. contains silver.
4th Group. Green ore	Bluish green, earthy carbonates of copper with bright red specks.	I. contains silver.
5th Group. Galenas	Bright large-grained galenas.	J.
	Cupro-plumbite, an ore of copper and lead in diagonally lamellar veins.	K.

A. is estimated to contain 30 to 40 per cent. of copper. It shows no trace of silver.

B. is simply an earthy inferior variety of the above.

C. This is a variety marbled with red and green earthy mixtures. It passes into gossan.

D. This is called a lead fahlerz; it contains 10 per cent. of lead and 32·7 of copper; it contains no trace of antimony, but 0·17 per cent. of silver is present.

E. Also a fahlerz with lead, but no silver.

F. resembles specimens of Peruvian pacos silver, 0·21, and copper 21·8 per cent.

G. also contains silver.

H. The silver estimated to be one-third less than in F.

J. Galenas, no silver.

K. Cupro-plumbite in thin veins forming alternate streaks of a bright and dull dark-blue grey galena-like mineral.

By the Mexican amalgamation process Mr. Piddington extracted silver from several of these ores. He was at first doubtful whether, owing to the high temperature and moisture of Calcutta, the process would be successful.

The report of the discovery of these ores created a good deal of excitement after the fact was announced; but at first the vision of a

new Peru in Deoghur caused a good deal of mystery to be employed. It does not appear that a regular company was ever formed, and the excavations along the outcrop, conducted by Messrs. Mackey and Co., not proving the existence of an extensive deposit, the matter was allowed to drop, though Mr. Barratt, a Mining Engineer, reported in glowing terms that the deposit was a champion lode, 9 feet thick, and the assays by Mr. Piddington and Messrs. Johnson and Mathey sufficiently attested to the value of the ores. That by the latter was as follows:—

Sample of copper and iron sulphide—

Copper	38·41
Iron	17·50
Lead	·90
Silver	·16
Lime	1·0
Silica and alumina	10·50
Carbonic acid	7·25
Sulphur	17·50
Water (combined)	3·45
Oxygen	3·30
Total	100·

At present, owing to the old excavation which extends for a distance of about 50 yards along the strike, it is not easy to see whether there is a true lode or not. The deposit certainly is in part included in a quartz veinstone, but it seems to permeate the schists and hornblendic gneiss; a crystalline pegmatite too is also impregnated with carbonate of copper in films and strings. By a little excavation samples of pyrites are obtainable too from this rock, and also some red oxide, but there is nothing now to be seen upon which a definite opinion can be formed as to the extent of the deposit.

Chutia Nagpur.—In this province copper ores occur in the following districts: in Manbhum at Purda and Kulianpur; in Singhbhum at numerous localities for a distance of 76 miles; in Hazaribagh at Baragunda; and in Palamow at Daltonganj. In all these localities the matrices of the ores are rocks belonging either to the metamorphic or sub-metamorphic series.

Manbhum District:[1] PURDA, Lat. 22° 59′ 15″; Long. 86° 37′ 45″.—About 1 mile north-east of the village of Purda or Poordah, which is in the pargana of Manbazaar, and 30 miles south from Purulia, there is an ancient copper mine, regarding the history of which nothing is certainly known.

[1] Records, G. S. I., Vol. III, p. 76.

That the exacavation was made for copper can only be gathered from the traces of the carbonates which are found on the debris scattered about. The deposit is situated along a line coincident with the position of the faulted junction of the metamorphic and submetamorphic rocks; and it seems probable, judging from the analogy to the deposits in Singbhhum, that the ore occurs partly disseminated in the schist and partly segregated in lodes.

Kalianpur, Lat. 23° 2′; Long. 86° 7′ 45″.—This locality is situated about 32 miles due west of Purda, and the deposit appears to be of a somewhat similar nature. There is an ancient exacavation on the flank of a small hill near Kalianpur, from whence ore was probably extracted, as some stains of the carbonates are to be seen, and a small quantity of copper slag still lies at the foot of the hill, indicating that the ore was smelted on the spot.

The occurrence of copper ores at Rajgaon, not far from Dhadka, where galena is found, has recently been reported, but the statement requires confirmation.

Singhbhum District.—The district of Singhbhum and the State of Dhalbhum include within their limits the most widely extended copper deposits at present known to exist in Peninsular India, traces of copper ores, often principally marked by old excavations, being found for a distance of 76 miles, or from the neighbourhood of Lopso, on the frontiers of Lohardaga, to Kamerara, on those of Midnapur. This deposit appears to exist on a well-defined horizon of the sub-metamorphic or transition rocks and close to their base; and it seems to be not improbable that the same horizon is represented to the north in Manbhum by the similar rocks which include the just-described copper ores close to and on the line of faulted junction between the submetamorphic and metamorphic rocks of that district.

As a rule the copper ores occur disseminated through the schists and the underlie of the deposit in general corresponds to that of the including rocks; but in some places the ores appear to be distributed in lodes, and the only safe conclusion to be drawn is that, as in some other parts of the world, there is a two-fold mode of occurrence, the lodes being of secondary origin and having been formed by segregation of the ores in fissures and fractures which were caused by the upheaval of the beds. If this be the true view, then the copper ores were originally deposited, either mechanically or chemically, at the same time as the other materials, and they were all together subjected to metamorphic action. Although it has been above said that the ore occurs in a zone in the submetamorphic rocks, there is one important exception which must not be overlooked. On the same general

line of strike the character of the rocks is locally interrupted in the neighbourhood of Kharsawan, where, in a small area, rocks are found, which are lithologically undistinguishable from those of the older crystalline formation, and in them the copper ores also occur. At first, supposing these rocks to really belong to the older formation, the conclusion might be drawn that the ores must necessarily occur in original lodes, coming from the deep throughout; but, on the other hand, if the possibility of a secondary formation of lodes be granted as above, then by filtration and transfusion from above, these ores may have been deposited in fissures in the deeper rocks which were at one time no doubt covered over by the younger copper-bearing strata. This explanation appears a more satisfactory one than that originally suggested, namely, that these gneissose and crystalline rocks of Kharsawan might merely owe their characters to excessive local metamorphism, and were not really older than the less crystalline rocks of the sub-metamorphic series.

Indications exist of mining and smelting having been carried on in this region from a very early period, and the evidence available points to the Seraks or lay Jains as being the persons who, perhaps 2,000 years ago, initiated the mining.[1] The number and extent of the ancient workings testify to the assiduity with which every sign of the presence of ore was exploited by these early pioneers and those who followed them up to recent times. The first published notice of the presence of copper ores in this area was by Mr. Jones in 1833.[2] In 1854, Captain (now Colonel) J. C. Haughton[3] published a description of the mines, and in the same year they were visited and reported on by Mr. Ricketts.[4] Under the auspices of two Calcutta firms, Dr. Stœhr came out to India soon after, and on his report a company was formed in 1857. Mining commenced at Landu and Jamjura, and from 1,200 to 1,300 cwts. of fine ore was turned out monthly. A heavy royalty of Rs. 9,200 yearly to the Rajas of Seraikela and Dhalbhum, an expensive establishment of Saxon miners and English smelters, the erection of a costly foundry and engine, and other premature and excessive expenditure led to the dissolution of the company in 1859. In 1862 an effort was made to start another company with a capital of £120,000; but by 1864 its operations had ceased. According to the prospectus of this second company the royalty was fixed at half the previous amount.

[1] Procdgs., As. Soc., Bengal, June 1869, p. 170.

[2] As. Res., Vol. XVIII, p. 170.

[3] Jour., As. Soc., Bengal, Vol. XXIII, p. 103, with map; in substance reproduced in a report by Mr. Durschmid, published in 1857.

[4] Selections from Records, Bengal Government, Vol. XVI, p. 77.

Numerous assays of the ores have been made, and these, with other details, will be found in the papers below quoted;[1] but the really important question was not definitely settled by the operations of either of the companies. It was as to the abundance of the ores. Good ore was met with at many points, yielding a high percentage of copper; but in most cases the unusual richness proved to be local and confined to pockets, and unremunerative, copper-permeated schist, or absolutely barren rock was found further to the deep.

At Landu, according to Dr. Stœhr, where the best ore was found, the cubic fathom of 96 to 150 cwts. of raw ore gave an average of 6 per cent. of copper, and the cost of the same, including haulage, amounted to Rs. 22 to Rs. 23 per 100 cwts. of raw ore; the average of 100 cwts. when hand-picked gave the following results :—

3	cwts. of	rich picked ore . . .	20 to 35	per cent. copper.
60	„	average ore . . .	8 to 9	„ „
13	„	dust ore	0 to 5	„ „
24	„	rubble and poor ore . .	¾ to 1½	„ „
100				

All the poor ore was regarded as rubble for crushing. In the best of it there occurred but 8 to 10 per cent., very seldom 20 per cent.

The mine at Landu was carried to a depth of 212 feet, but at 190 feet the ore had died out; whether there only happened to be an interval of poor ground there, and richer ore occurred further to the deep, it was impossible to say.

Copper pyrites was first struck by the second company at Rajdoha just before operations ceased. All the ore previously obtained had consisted of the carbonates and oxides and some glance copper with traces of other rarer ores. In Dr. Stœhr's time but little pyrites had been met with.

Traces of silver were found in some of the samples which were assayed, but not in all. The results are quoted in Chapter IV. A very small percentage of the precious metals sometimes enables inferior copper ores as at Eisleben, in Prussian Saxony, to be worked with profit, though the actual manufacture of the copper may itself be carried on at a loss.

Should the proposed line of railway to the Central Provinces traverse Singhbhum, this copper deposit may yet prove of value, the accessibility to Calcutta being by this means so greatly increased. The following table contains an abstract of the information available from an examination of the localities by the writer in the year 1869 :—

[1] Records, G. S. I., Vol. III, pp. 86 and 94.

Copper Ores of Singhbhum.

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.	Ore.	Rock.	Remarks.
Raja of Dhalbhum.	1	Madhopur, 3 miles north of Kumrara.	2	Outcrop excavations.	...	Traces of carbonate: a specimen yielded, according to Colonel Haughton, 24¾ per cent. of copper.	Quartz and black mica schist, strike 10° east of north, granite close by.	These mines are full of water, to remove which and renew excavation would be necessary before the condition of the ore could be ascertained.
	2	Hills, W. of Asunbuni .	Numerous.	Ditto ...	40° E. N. E.	No traces of ore *in situ*.	Black and grey mica schists.	Slag close by, indicating that ore was once found.
	3	Hills, S. E. of Badia .	...	...	...	...	...	This locality is given by M. Stœhr.
	4	Badia	Very numerous .	Ditto and shafts	40° to E. 25° N.	Traces of carbonates abundant.	Grey and black mica schists, strike 25° west of north. Towards Mosabuni gneissose rocks strike more to north.	The relative positions of the Badia excavations indicate four distinct outcrops of ore. The principal of these passes through the village of Badia, near which are great heaps of slag. This was evidently a centre of extensive operations.
	5	Mosabuni	Numerous.	Out crop excavations.	Ditto.	Ditto.		
	6	Surda	12	Ditto . .	?	No trace of ore at present exposed.	Schists.	
	7	Hills, W. & W. N. W. of Surda.	Numerous.	Quarries, shafts, inclines.	40°	Incrustations of the carbonates on the walls.	Black mica schist . .	From the abundance of slag it would appear that here, as at Badia, considerable quantities of ore must have been smelted by the ancients.
	8	Hills, W. of Teringa and Kendadih.	Ditto ..	Outcrop excavations & inclines.	30°-35° E.N.E.	Traces of carbonates rare.	Mica schist.	
	9	Sideshur Hill, S. of Ruam	3 to 4	Ditto & shafts	35° N.E.	Traces of slag abundant.	Ferruginous mica schist .	At the site of the old town of Ruam, there are several tanks covered up by jungle and immense quantities of slag.

Raja of Dhalbhum.	10	Mahadeo Hill	...	...	...	...	...	This locality is given by M. Stœhr.
	11	Baghghura	Several	Inclines	...	Ditto	Mica-schist.	
	12	Hills, S. & S. W. of Matigara (=Raga of Dr. Stœhr.)	Numerous.	Ditto & shafts	N. E.	Ditto	Ditto	A number of deserted potstone mines, some which are still worked, occur along this range.
	13	Rangamatti Hill, S. E. corner, N. of Banjo.	1	Shaft	...	Traces of carbonates	Ditto & quartzite	Incrustations of the carbonates and black oxides occur on the quartzites forming the main axis of the hill.
	14	Rajdoha *a*	1	Incline & adit	...	Ditto	Slaty blue schists	These are situated on a spur of Rangamatti.
		Ditto *b*	1	Incline	25° N. N. E.	Ditto	Ditto	These were worked by the Copper Company. But the pyrites was only just reached a short time before working was discontinued; *d* is west of the river, *b* and *c* being to the east.
		Ditto *c*	1	Shaft	Ditto	Copper pyrites	Ditto	
		Ditto *d*	1	Incline	Ditto	Traces of carbonates	Ditto	
	15	Matku	1	Shaft	...	Carbonates, traces of red copper and pyrites.	Greenish talcose schist and quartzo-felspathic grit.	
	16	Hurtopa	1	Ditto	...	No ore seen	Quartzite.	
	17	Hitku	1	Ditto	...	Traces of carbonates	Schist and quartzite	Originally commenced by the ancients; it was deepened by the Company, but has subsequently become filled up.
	18	Landu Barutghur Hill	Numerous.	Shafts, inclines, adit, trench.	35°—55° to 10° E. of N.	Ditto	Quartz and mica-schist much contorted and baked. Banded jaspery quartzites close by.	A considerable amount of ore appears to have been obtained here by the Company. M. Stœhr's papers give the details of workings carried on at Landu.
		Landu Chundra Hill *b*	Ditto	Inclines	Ditto	Ditto	Schist.	

Copper Ores of Singbhum—contd.

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.	Ore.	Rock.	Remarks.
Raja of Dhalbhum.		Landu Chundra Hill, N. of Turamdih *c.*	Numerous.	Inclines	40°—50° N., or 10° E. of N.	Traces of carbonate	Contorted talcose quartzite and micaceous schists.	These works were chiefly made by the Company, but all along the outcrop of the schists there are ancient excavations. In one place the ore permeates 6 feet of rock.
		Ditto Hill, N. of Tulsa *d.*	Ditto	Ditto & adit ...	40° N.	Ditto	Ditto	The mines here were worked by the Company.
Koer of Seraikela.	19	Jelling {gora, bera}	2	Shaft and incline.	?	Ditto	Talcose and mica schist.	
	20	Jamjura *Tschamtschura* of M. Stœhr.)	Several	Shafts	...	Ditto and grey copper.	...	These shafts were worked by the Company: one of them fell in while the operations were going on. Samples of ores yielded 52·0 and 44·5 per cent. respectively.
	21	Gura	0	...	...	Traces of carbonates	Schist	No mines opened at this locality.
	22	Tamba-dungri	6 ?	Shafts	25° N.	Ditto	Sandy and fibrous mica schists.	Shafts in very irregular positions and without reference to the lie of the deposit.
	23	Saldih	1	Ditto	N. N. W. 50°	No trace of ore.	Mica schists.	

Koor of Seraikela.	24	Mundra	1	...	N. N. E. 40°	Ditto . .	Soft satiny felspathic and talcose schist.	Said to have been excavated by the father of the present Baboo of Dugni, Rungit Singh.
	25	Dugni	0	0	60° N.	Traces of carbonates	Mica schists . . .	This is situated in the village of Dugni; there has never been any excavation.
	26	Ukri	1	Outcrop excavation.	"	Ditto abundant, a specimen yielded 36·5 per cent. of copper.	White talcose mica schists and granite gneisses.	Said to have been worked with profit by the Dugni Baboo about three years ago (i.e. 1866.)
	27	Komulpur (Banksai) .	1	Ditto . .	?	Ditto . .	Schists and gneiss.	
Thakur of Kharsawan.	28	Akarsuni a	Several .	Ditto . .	N. W.	Traces of carbonates	Schists, granitic gneiss and trap close by.	A series of excavations in the fields are nearly filled up with surface soil.
		" b	1	Ditto . .	?	Ditto . .	Ditto.	
	29	Podampur	2	Ditto . .	?	Ditto . .	Mica schists and quartz...	Rocks much covered; no strike apparent.
	30	Begadih	4 (a—d) .	Ditto . .	?	Ditto . .	Micaceous and quartzose schists, also gneiss and trap close by (c).	Copper is said to have been manufactured from ore extracted from (d) twelve years ago (i.e. 1857.)
	31	Lopso Hill . .	1	Ditto . .	40° N.	Ditto . .	Coarse mica schists .	Situated at foot of the hill west of Kanrudih.

Hazaribagh District: BARAGUNDA, Lat. 24° 4′ 3″; Long. 86° 7′.—This locality is stated to be so called from the fact of its being the site of 48 (*bara-gunda*) ancient copper mines. It has been described by Dr. McClelland[1] and Mr. D. Smith.[2] Mr. Piddington[3] has also published an account of his analyses of the ores. From these sources of information and the observations made by the writer during a brief visit, the following account has been drawn up.

The excavations which mark the position of these ancient mines are situated along a line of outcrop of metamorphic rocks, which form a ridge, about three-fourths of a mile long, between the villages of Parsabera and Baragunda. At the eastern end the ridge commences with a small hill, which rises to about 60 or 70 feet above the cultivation of the village of Parsabera, and thence westwards it slopes down to the level of a small stream which is about 70 or 80 feet below the base of the hill. The rocks forming the ridge are a somewhat granular quartzite passing into gneiss, alternating with micaceous talcose, hornblendic and actinolite schists, the micaceous and talcose varieties being not unfrequently garnetiferous. The principal gangue stone appears to be a semi-pellucid quartz, but the ore also occurs disseminated in the schists. The general strike of these rocks, as also of the line of excavations, is from east to west, varying locally to from 10° south of east to 10° north of west. The dip or underlie is nearly vertical.

At the present time, without making special excavations, traces of the ore are to be seen *in situ;* these consist of stains and encrustations on the faces of the rocks exposed by the old excavations, and in the refuse heaps fragments of quartz, which include samples of ore, are to be met with. A very fine series, illustrative of the ores obtained partly from recent, partly from former excavations, is now in the Museum of the Geological Survey. Both the oxides and sulphide of copper occur in these specimens, and associated with them are galena and zinc blende. In some of these the matrix is the schist. Mr. Piddington's assay was as follows:—

Silica	0·50
Sulphur	31·42
Iron (Perox., 48·55) metallic	33·98
Copper, metallic	34·10
	100·0

[1] Report of the Geological Survey of India, Calcutta, 1850, p. 23.

[2] Report of the Sigrowlee and Karharbari Coal-fields: Calcutta, 1857.

[3] Jour., As. Soc., Bengal, Vol. XXII, 1853, p. 311.

We are not in possession of any information as to who the ancients were who made the numerous excavations at Baragunda, of which ample evidence is still to be seen. These workings extend all along the outcrop, and from their overlapping in places it would appear that the deposit was not limited to one line of strike. Though in some cases the samples show that the ore occurred as a constituent of the schist, others seem to justify the conclusion that there are one or more distinct lodes parallel to the bedding.

Along the main line the width of the excavations average from 25 to 30 yards. The miners appear to have thrown the debris behind them as they progressed, the depth to which they could go being limited; thus there are a succession of basin-like pits separated from one another by mounds of debris, and bounded by the faces of rock which form the foot and roof of the deposit. Dr. McClelland describes and figures a system of mining in steps on the face of the hill; but this feature has now disappeared, if it ever existed on the scale which he mentions. Certainly the term 'mountain,' which he applies to the small hill, is not applicable. No doubt by weathering and the growth of jungle, the form of the ground has been much modified during the thirty years which have elapsed since he wrote. Dr. McClelland mentions the occurrence of large mounds of copper slag which he says cover several acres of ground at the village of Giridi[1] (Gereedee), about 2 miles distant, where, in the vicinity of fuel and water, smelting was carried on.

From these remains and the extent of the excavations, it seems to be legitimate to conclude that this deposit was worked for many years, and that it was only relinquished when the readily accessible part of the back of the lode had been exhausted, and when the native miners found themselves unable to cope with the difficulties arising from having to go to greater depths.

In or about the year 1854, a Mr. Mackenzie is said to have sunk a shaft to a depth of 17 feet, but afterwards abandoned it. His reason for having done so is not known, as no actual record of his operations appears to have been preserved. Within the past few years there has been another attempt, on a small scale, to test the value of the deposit; but the heavy royalty claimed by the zemindar, the Raja of Palganj, has hitherto been unfavourable to all attempts to re-open these mines.

The situation of the deposit is favourable to mining operations, as an adit level or gallery might easily be driven from the stream eastwards

[1] This is not to be mistaken for the Giridi Station on the E. I. Railway, which is about 24 miles distant from Baragunda.

with the line of strike, and well below the bottom of the lowest native workings. This would serve not only to test the deposit throughout, but it would also facilitate subsequent drainage.

The vicinity of such a supply of fuel as that afforded by the Karharbari coal-field and the means of carriage afforded by the railway confer upon this deposit obvious advantages over many others in India.

Lohardaga District: DALTONGANJ.—During the sinking of a well in the station of Daltonganj, some traces of copper ores were discovered disseminated in beds of schistose gneiss by Mr. L. Forbes.

The section was examined by Mr. Hughes,[1] who thought it did not give promise of a workable deposit. The ore was in four horizons, aggregating a total thickness of 4 feet 10 inches in 26 feet of section. The dip was 4°, and there was no sign of a true lode.

KASIANUAN.—In a letter from Mr. T. Marriott to the Collector of Burdwan, dated April 6, 1809,[2] the occurrence of copper ore is thus alluded to, coal having been said to exist near a place called Thoorah, on the southern side of the Sone river, three *coss* above the Koel river, and also in the bed of the Bucooah, only a mile from 'Kussyaun,' a well-known place, "near which Mr. Prinsep, many years ago, found copper and commenced an extensive manufacture of vitriol." Information recently received from Mr. C. E. Davies of Rotasgarh has served to clear up the origin of this tradition as to a source of copper. There was a manufactory of *kasis* or copperas at Tilkap, 6 miles from Rotasgarh, on the road to Dehri. The manager lived at Kasianuan, and the copperas used to be stored there. The material used in this manufacture will be described in Chapter VIII. It may be added that the neighbourhood of the Sone has been noted for imaginary discoveries of coal.[3]

Central Provinces.—Copper ores are known to exist in the following districts and localities in the Central Provinces: In Raipur at Chicholi; in Jabalpur at Sleemanabad; in Narsinghpur at the Birman Ghât; and in Chanda near Thana Wasa.

Raipur District: CHICHOLI, Lat. 21° 5′; Long. 80° 41′.—Traces of the copper carbonates have been observed at the locality described below, where galena occurs; and in a similar and parallel vein of quartz at Wararband, 14 miles to the east, stains of the carbonates were also seen.[4] In the former case the reef traverses metamorphic rocks, but in the latter it is on the line of contact between these and Lower Vindhyans.

[1] Settlement Report and Mem., G. S. I., Vol. XV, p. 125.
[2] Jour., As. Soc., Bengal, Vol. XI, p. 830.
[3] Mem., G. S. I., Vol. XV, p. 7.
[4] Records, G. S. I., Vol. X, p. 185.

Jabalpur District: SLEEMANABAD, Lat. 23° 38′; Long. 80° 19′.—Some traces of copper ores (malachite and oxide) were discovered on a bed of Bijawar quartzite in the neighbourhood of Sleemanabad by Mr. W. G. Olpherts, and in the same association a small quantity of galena was also found. According to Mr. Hughes,[1] who subsequently visited the locality, there was no indication of a true lode, and the ores of the metal appear to have been only sparsely disseminated in the rock.

Narsingpur District: BIRMAN GHÂT, Lat. 23°2′; Long. 74°5′.—Copper ores were first discovered to exist on a small island in the bed of the Narbada river, in the year 1873, by Mr. C. Maynard, manager of the Narbada Coal and Iron Company, who shortly afterwards commenced mining with the result, as reported, that a quantity of the ore which was sent to England paid its expenses.

This deposit does not, apparently, form a true lode, the ore being disseminated through an argillaceous schist, which is associated with quartzites of the Bijawar series. Shortly after the mine was opened the band of rock permeated by ore was found to be about 6 feet thick.[2] The result of subsequent operations is not on record, but the mine was ultimately abandoned.

The blue and green carbonates, azurite and malachite were notable, as compared with those from most other Indian localities, for their very bright colours. Grey and red oxides were also met with. The following percentages of copper were obtained from seven of the early samples of the carbonates:—

	A.	B.	C.	D.	E.	F.	G.
Copper . . .	32·75	23·1	47·8	21·2	32·2	25·4	12·6
Iron . . .	2·50	5·4	52·2	78·8	68·8	74·6	87·4
Earthy matter, &c .	64·75	71·5					
	100·	100·	100·	100·	100·	100·	100·

the average yield being, therefore, 28 per cent.

Chanda District: THANA WASA, Lat. 19° 51′; Long. 79° 47′ 50.″—On the atlas map of India a spot near the above-named locality is marked as having been the site of an ancient copper mine, but no further information on the subject is at present available save that in the Central Provinces' Gazetteer[3] it is stated that tradition points out localities in the north of the district where copper is said to have been once mined.

[1] Records, G. S. I., Vol. III, p. 70.
[2] *Op. cit.*, Vol. VII, p. 62.
[3] 'Chanda,' p. 135.

Rewah and Bundelkhand.—So far as is known, the copper deposits of these provinces are not of great extent, but our information regarding them is not very complete.

Rewah State: BURDI, Lat. 24° 33′; Long. 82° 26′ 30″.—This locality, which is close to the junction of the Gopat and Sone rivers, is indicated on Captain Sherwill's geological map of Bengal as being one where copper has been found. Since the locality is on lower Vindhyan rocks, and since it appears from the old mineral register that a specimen received from Captain Sherwill from that locality in 1852 consisted of metallic copper, it may perhaps be doubted whether there ever was a *boná fide* discovery there of ore *in situ*. Though galena has been found in rocks of this age there is no recorded case of the discovery of copper.

TAGWA,—Lat. 24° 16′ 30″; Long. 82°.—Somewhere between the villages of Tagwa and Baramdeo Captain Sherwill also represents copper ore as having been found. The rocks in the vicinity are slates in the lower portion of the Bijawar series. The occurrence of copper ores in these rocks is not without a parallel, since those at Birman ghât, on the Narbada, are in beds of the same age, and in many parts of the country the local groups of transition rocks are copper-bearing.

Bundelkhand: **Shahgarh District**: SAURAI.—Near the village of Saurai, in the Shahgarh district, a deposit of copper, which it is said was formerly worked to a considerable extent, has long been known to exist.

Mr. Medlicott states[1] that he was shown by Major Ellis at Nagode, samples of grey copper said to have been extracted from a trench near the village, but no traces of the ore were then to be seen on the spot. Subsequently, the locality was visited by Mr. Mallet,[2] who states that a pit which had been sunk by the Assistant Commissioner, in order to test the report, was situated in a fissure "formed on a joint in the Bijawar limestone heading north-east to south-west, the walls of which were 12 to 15 inches apart. This fissure had been filled up with clay and pebbles of various kinds, Bijawar limestone, hornstone, Bijawar ferruginous rocks, Vindhyan sandstones, but none of the crystalline rocks."

At 6 feet from the surface rolled lumps of copper ore, mixed with pebbles of the other rocks, were found, but neither here nor in the neighbourhood was any lode or ore *in situ* discovered. Mr. Mallet expresses his belief that the lode, if it exists, is situated in the Bijawar rather than in the crystalline rocks. It is pretty clear that the natives had concealed the deposit for some reason.

[1] Mem., G. S. I., Vol. I, p. 35.
[2] Records, G. S. I., Vol. I, p. 16.

Whether Mr. Mallet's suggestion as to a system of pits being made in order to trace out the deposit has been acted upon by the local authorities does not appear. It is said[1] that 12 seers of copper were manufactured from a maund of the ore which was found.

Rajputana.—Copper ores are found in several of the independent States of Rajputana, and also in the British district of Ajmir. Mining has been practised on a large scale, but at present the trade of the miner is becoming extinct, and the operations, which are only carried on in a few of the localities, are of a very petty nature.

The names of the States in which there are mines are as follows: Alwar, Bhartpur, Jaipur, Udepur, Bundi, and Bikanir.

Alwar State.—According to Mr. Hacket[2] there are ancient copper mines at the following localities in this State: Daribo, Indawas, Bhangarh, Kushalgarh, Baghani, Partabgarh, Tassing, and Jasingpura. The most important of these is the first.

Daribo, Lat. 27° 9′ 30″; Long. 76° 26′ 20″.—The mine is situated on a sharp anticlinal bend in a thin band of black slates intercalated in the Alwar quartzites. There appears to be no true lode; the ore, which is pyrites mixed with arsenical iron, occurs irregularly disseminated through the black slates, a few specks and stains only being seen in the quartzites; occasionally rich nests of ore were met with. The operations of the natives were much facilitated by an adit level made under the direction of Dr. Impey, and which served to drain the pits. Mr. Hacket says, however, that this mine is now nearly abandoned. From an interesting account by Major Cadell,[3] the following facts regarding the manufacture have been extracted. The ore, as usual in the native process, is pounded, made up into balls with cowdung, roasted, and then smelted in a closed furnace and refined in an open charcoal fire. Thirty pounds of ore require four times that quantity of charcoal, and yield 5½ pounds of metal, or 16·6 per cent. During the last 12 years the average annual outturn has been only 3 tons 8 cwts., and it is diminishing owing to the influx of European copper. The State claims one-third as royalty; 32 families, including 88 persons, derive their principal means of subsistence from this industry. Small quantities of the sulphates of copper and iron are manufactured from the waters of these mines.

Jodawas or Indawas, Lat. 27° 21′ 30″; Long. 76° 23′ 30″.—Mr. Hacket saw here a long open cutting, 20 to 30 feet deep, from which copper ores had been extracted; it was then full of water.

[1] Gazetteer of the North-West Provinces, p. 325.
[2] Records, G. S. I., Vol. X, p. 91.
[3] Gazetteer of Ulwar, p. 82.

BHANGARH, Lat. 27° 5′ 30″; Long. 76° 22′.

KUSHALGARH, Lat. 27° 25′ 30″; Long. 76° 30′.

PARTABGARH, Lat. 27° 15′; Long. 76° 13′ 30″.—The workings at these localities have long been deserted; according to the natives those at the last were very extensive; they suddenly fell in, burying a large number of the miners. Traces of ore were seen at Tasing, in the Mandan hills, and at Jasingpura near the railway.

Bhartpur State: NITHAHAR, Lat. 26° 58′; Long. 77° 5′.—There is an abandoned mine at this locality, which is close to the Jaipur frontier. Copper works formerly existed at Basawar in this State. The metal produced was better than that at Singhana, but the ore was too poor to be worked with profit.

Jaipur State.—In this State copper ores are reported to exist at the following localities: Singhana, Khetri, Nabaro, Udhalha south-east of Garh, Lalsot, Bagor, and Babai; of these the most important are the first two and the last.

SINGHANA, Lat. 28° 5′; Long. 75° 53′.—The copper mines at Singhana are situated in rocks belonging to the Arvali series. The earliest account of these mines, which is believed to have been by Captain Boileau, was published in the year 1831.[2] The principal productions were copper, blue vitriol or copper sulphate, alum, and an ore of cobalt called *sehta* or *saita*, which will be described in Chapter VII.

The mines are described as being tortuous and of great extent; at the working faces it was the custom to light fires which caused the rock to split up. Lamps were used which the miners carried on their heads and with a gad and hammer extracted the ore. The principal ore found appears to have been pyrites. It was sold retail by auction to the proprietors of different furnaces.

The pounding or crushing was effected on a stone anvil with a hammer weighing eight or ten seers; when completely reduced to powder the ore was made up into balls with cowdung and roasted. The blast furnaces, *vide* Plate IX, were prepared in the following manner. A quantity of common sand was spread on the floor of a circular hut, in the centre of which a depression, 12 to 15 inches in diameter and 2 or 3 inches deep, was made; in this a layer of fine sand and another of ashes were laid to prevent the metal from adhering to the bottom of the receiver; two clay nozzles or twyers were then placed on opposite sides of this hollow and a third between them, leaving the fourth side vacant for the slag to escape. The nozzles were then connected by moist clay,

[1] Gleanings in Science, Vol. III, p. 380.

[2] *Idem*, p. 384.

and a circular rim of mud, a few inches in height, was raised, on which three annular vessels of fire-clay were placed to form the body of the furnace; each of these was 15 inches in external diameter, 10 inches high, and 3 inches thick. They were used repeatedly, but the lower part of the furnace had to be reconstructed for every charge. The bellows were simply goat-skins connected with the nozzles, and were worked by the families of the smelters. After a preliminary firing, to dry the mud, the furnace was charged with charcoal, roasted ore, and iron slag, the latter being employed as a flux.

In a day of nine or ten hours' duration, 3 maunds of charcoal, 2½ of the roasted ore, and 2 of the iron slag were consumed. The slag was drawn off and the smelted copper which had accumulated at the bottom of the furnace was removed on the following day. It was then re-melted and refined in an open furnace under a strong blast from bellows, and cast into small bars or ingots, which were subsequently removed to the Mint and cut up and fashioned into coins.

The ore was said to yield only from to 2½ to 7½ per cent. of metal, but the profits must have been not inconsiderable as the Khetri Raja is said to have claimed one-sixth of the value of the copper in addition to Rs. 14,000 received for the lease. The quality of the metal is said to have been inferior to that of Basawar, this being attributed to the use of the iron slag as a flux.

The present condition of these mines is thus described by Mr. Hacket.[1] The principal mine is entered by a wide gallery driven into a ridge of quartzite with the strike, and at a point several hundred feet above the level of the plain. This gallery is in places 50 or 60 feet wide and of considerable height. For the first hundred yards the descent is slight, afterwards it becomes steep, and three separate galleries strike off into the hill. In these galleries there is hardly a trace of ore left and the ends of the mine are concealed by fallen debris and water. The mine has been abandoned in consequence of the poverty of the ore. Towards the entrance, strings and small veins of ore are seen in the quartzite. Mr. Hacket considers that valuable pockets of ore might be found in the unworked ground between this mine and Khetri, as they are on the same line, as is also the mine at Babai.

Considerable quantities of blue vitriol (copper sulphate) alum, and copperas (iron sulphate) are manufactured from the decomposed slate and refuse of the mines. The slates are steeped in water, which is afterwards evaporated in large iron vessels, when the blue vitriol is crystallized

[1] Records, G. S. I., Vol. XIII, p. 246.

out, afterwards the alum, and lastly the copperas. Mr. Mallet found traces of nickel and cobalt in all three of these substances.

KHETRI, Lat. 28°; Long. 75° 50′.—A very full account of the Khetri mines and manufacturing processes, illustrated by numerous plates, was published by Colonel J. C Brooke in the year 1864. Many of the details which are given are naturally almost identical with those which have been just enumerated in reference to Singhana, which is only 8 miles distant to the north-west. Indeed, Singhana is partly included in this description, as it belongs also to the Raja of Khetri.

The miners are said to be the poorest of the population; those who work the ores are Mahomedans, and the manufacturers of alum and the copper and iron sulphates are Hindus.

The Kulhari mine is, like others described elsewhere, a tortuous warren, enlarging here and there, where pockets of ore were discovered. The only means of overcoming the influx of water known to the miners is by passing *gharas* of water from hand to hand through the passages; in one case no less than 27 men were thus employed for upwards of a month, at a cost of Rs. 200.

The mines are in most cases owned by the miners themselves, whose ancestors discovered them, but some have passed into the hands of the money-lenders. The permission to work the different branches of the mine is put up to auction annually, after the rains, and bought by gangs of eight.

The ores are sold in the town of Khetri by auction to Mahomedan Bhoras, who conduct all the subsequent operations, which are nearly identical with those described above in the case of Singhana. The refuse from iron furnaces, called *reet*, is still used as a flux. An expenditure of about Rs. 7-11 on smelting five maunds of ore yields 303 *takas* of copper, from which one-fourth must be subtracted for the royalty, and the remaining 228 *takas*, worth Rs. 9, will be left. The profit is, therefore, about Re. 1-5, or allowing for extras Re. 1.

The manufacture of alum and copper sulphate is, as at Singhana, carried on actively here also, and the process of steeping the shale in earthen *gharas*, arranged on ledges on cones formed of old refuse, is fully described by Colonel Brooke (see Chap. IX).

Mr. Hacket's[1] still more recent account of the Khetri mine is that it is situated on a ridge of slates, about 500 feet above the plain. It is entered by several shafts of considerable depth, which give access to a gallery said by the miners to be upwards of 2 miles! in length. The direction of this gallery appeared to be parallel to the strike of

[1] Records, G. S. I., Vol. XIII, p. 245.

the slates. The ore now brought up from the old workings is pyrites, which occurs disseminated through the slates.

The almost complete abandonment of these mines is attributed to the partial failure of ore and consequent increased expenditure, while the Jaipur Darbar has refused to reduce the royalties.

Babai, Lat. 27° 55′; Long. 75° 49′.—These mines are situated about 8 miles south of Khetri, and on the same band of slates in which a small proportion of ore occurs disseminated, but the principal object of the pits is to search for *saita* or cobaltite.

The other mines in the Jaipur State, which have been above enumerated, need not be further described; indeed, full details regarding them are not available.

Ajmir.—In Ajmir the occurrence of copper ores has been noticed by several writers. They have been found at Gugra, 4 miles north-north-east of Ajmir; at Rajauri, 10 miles south-west of Ajmir; and Rajgarh, 12 miles south-south-west of Ajmir; and in Ajmir itself.

Gugra, Lat. 26° 29′; Long. 74° 43′.—The deposit here was described by Captain Dixon in 1835,[1] and was said to be from a span to 4 inches in thickness; it was opened up by a mine. A sample of the ore was described by Mr. Prinsep, who says that the malachite was associated with carbonate of lead, a micaceous carbonate of iron, and a rich galena. Yellow copper pyrites was also present and earthy veins of a pale blue, very similar to some of the streaks in the turquoise rocks of Nishapur, in Persia. He suggests the possibility therefore of turquoise being found in Ajmir.

Rajauri (? Rajori), Lat. 26° 20′; Long. 74° 44′.—Captain Dixon also speaks of a mine having been opened at this locality. The ore appears to have been carbonate.

Rajgarh, Lat. 26° 18′; Long. 74° 41′.—A mine was opened here at about the same time. The ore was, according to Mr. Prinsep, accompanied with slender prismatic crystals of selenite, black augite, red oxide and carbonate of iron, and a mineral containing copper which seems to have been chrysocolla.

Ajmir, Lat. 26° 28′; Long. 74° 41′ 30″.—Mr. Hacket states that there are traces of copper in the old iron workings near the jail at Ajmir.

Udepur State: Rewara.—At Rewara, near Gungapur, according to Mr. Hacket, a number of small pits are sunk in the schists in a north and south line for nearly a mile. The copper slag found on the spot seems to indicate that no very large quantity was found.

[1] Jour. As. Soc. Bengal, Vol. IV, p. 583.

Bundi State: DATUNDA, Lat. 25° 27′; Long. 75° 30′ 30″.—Two miles east of Datunda a small pit was sunk in quartzites, upon which traces of copper were still to be seen when examined by Mr. Hacket, but there did not appear to have been much ore there.

Bikanir State: BIDASAR, Lat. 28° 15′; Long. 72′ 55°.—It is not known whether the now deserted copper mine at this locality, a few miles from Sujangarh, was worked with profit; but its discovery in 1753 created much interest.[1]

Bombay: Dharwar District.—Attention was drawn by Captain Newbold[2] to the Kappatgode range, in the district of Dharwar, as containing a possible source of copper in consequence of traces of copper ores and a fragment of native copper having been met with in the gold washings in the Doni rivulet; but it does not appear that any ore *in situ* has ever been discovered in that region, except some stray little masses of copper pyrites in a *pseudo*-diorite which were found by Mr. Foote.[3]

Balochistan: LAS DISTRICT.—In the district of Las, between the towns of Liyari and Bela, there is stated to be a hill where copper ore is obtainable in abundance. In the year 1840 Captain De la Hoste[4] very closely interrogated a man then living at Karachi, who stated that together with his father he had visited the hill, which was 12 *coss* south of Bela, and had manufactured a small quantity of copper on the spot, the ore yielding 50 per cent. Subsequently they applied to the Jam for permission to work the mine, and he seemed at first willing to grant it; but on being told by one of his followers that if he did he would lose his country, he informed the Karachi men that they must leave forthwith, and that if they were ever caught near the copper hill again he would cause them to be burned alive. Mr. Hughes,[5] quoting from Captain Hart, apparently alludes to the same story. Mr. Griesbach refers to this locality as Shah Bellawl, 20 miles south-east of Bela.

Major George LeMessurier[6] recorded that there are mines of inferior copper ore near Turkabr, but that the exact locality was kept a secret by the people of the country.

Afghanistan.—Several writers, but more particularly Captains Hutton[7] and Drummond[8] testify to the abundance of ores of copper in

Gazetteer of the Bikanir State by Capt. P. W. Powlett, p. 97.

Jour. Roy. As. Socy., Vol. VII, p. 150; Madras Jour. Lit. and Sci., Vol. XI, p. 42.

Records, G. S. I., Vol. VII, p. 140.

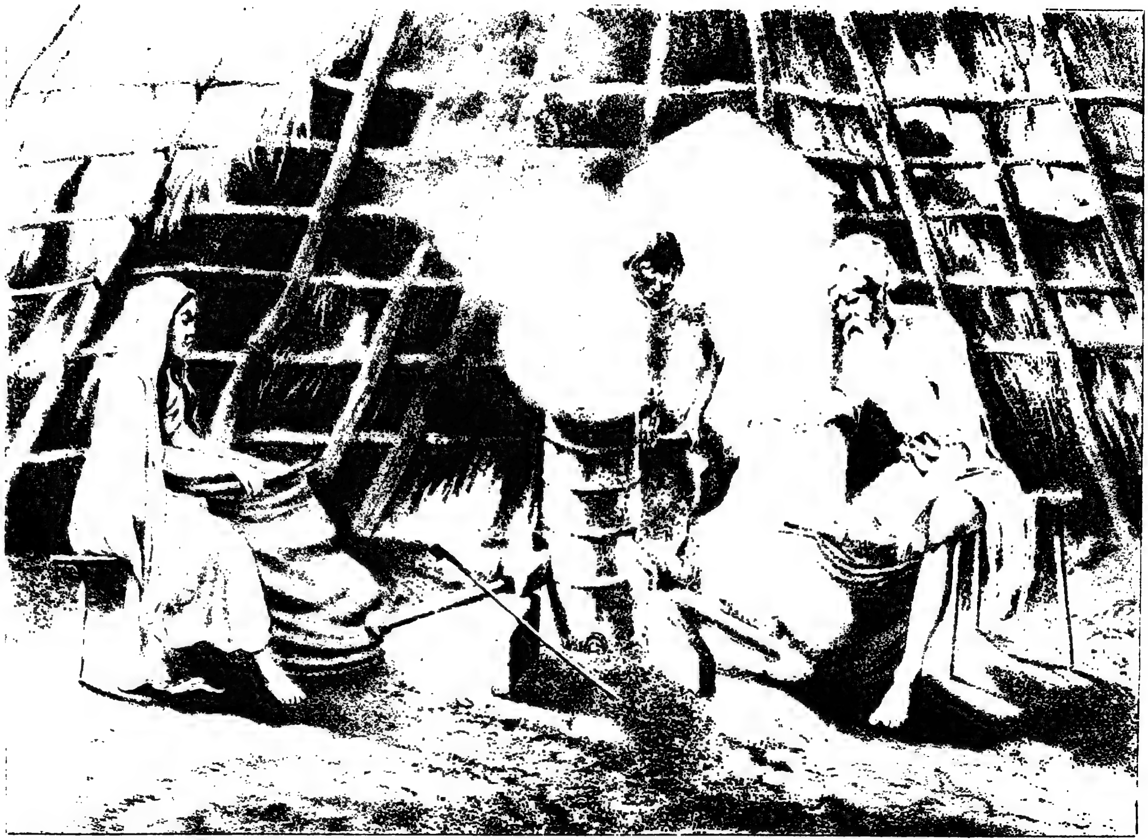
Trans. Bomb. Geol. Socy., Vol. VI, p. 117; Jour. As. Soc. Bengal., Vol. IX, p. 30.

5 'Balochistan,' p. 22.

6 Bomb. As. Socy., Vol. II, p. 100.

7 Cal. Jour. Nat. Hist., Vol. VI, p. 597.

8 Jour. As. Soc. Bengal, Vol. X, p. 74.



COPPER REDUCING FURNACE AT KHETRI.

Afghanistan. The remarks by the former refer to the southern portion of the country, and those by the latter to the northern; in several cases the ores have been mined to a considerable extent; but the copper used in Kandahar in Captain Hutton's time was supplied partly from Bombay and partly from Persia.

KOJAK AMRAN RANGE.—Specimens of copper ore in a white quartz matrix from this locality were considered to be poor by Captain Hutton.

SHAH MAKSUD RANGE.—A rich ore of copper exists on this range; it is said to have been first worked by Nadir Shah and subsequently by the Sirdars of Kandahar. The statements made to Captain Hutton represented the profits as amounting to 1900 per cent., which he considered to be an exaggeration. Forced labour was employed in mining.

NISH.—A rich ore of copper is said to occur in Nish, about 60 miles to the north of Kandahar.

HAZARA MOUNTAINS.—The blue and green carbonates of copper and the red oxide are obtained in some parts of these mountains.

Captain Drummond describes a copper-yielding region between Kabul and Kuram; many of the names which he mentions do not appear on the maps; they are as follows: Moosye, in the pass of Shadkhannee; on the right bank of the Lagur river, west of the village of Kuttasung; in the pass of Silawat, to the east of Kuttasung; Koh-i-chagye; various points in the Silawat Pass; Koh-i-Aeenuk; Seestungee; Baghye; Dundhanee, in the direction of Jowhar, to the south of Rotil-i-Dushtuk; Acooroökhail mountains; Dherband in Tungee Khooshk; Kila Ataye; Tezeen; Khoondurra; Dobundee; Lahazour near Shinkye; Chinarkhail; Jerobaee. At all of these localities, which are spelt here as they are in the original, copper ores were found, and at some of them there are ancient copper mines of considerable extent. The rocks are metamorphic schists, principally hornblendic; it seems doubtful whether the ore exists in true lodes as the courses are parallel to and dip with the bedding. Tezin, lat 34° 24′, long. 69° 30′, is the most eastern point of the cupriferous tract, and Wurduk the most western; Spega to the south and the hills about Kabul to the north indicate the known limits in the other directions.

The most promising veins are said to be those of Dherband and Dobundee, and among the old mines that at Koh-i-Aeenuk holds out the best prospects.

The results of the assays of the purple, vitreous and cuprite ores yielded, respectively, 60, 80, and 90 per cent. of metal. Captain Drummond's conclusions as to the mining prospects of the area are as follows. The number of veins which have been discovered show that the strata

are highly metalliferous; the quality of the ore is excellent; from the extent and depth of the excavations it is concluded that the ore, if it did not increase, certainly did not diminish, as otherwise so many localities where ores occur at the surface would not have been left untouched. From the nature of the ground, drainage could be effected easily, and in some cases adits might be driven in from levels below the old workings. In some of the localities the supply of water might be short, but in others it would be abundant. It is stated that the forests which stretch from the Sufedkoh southwards would furnish an ample supply of timber for the mines and wood for charcoal.

Colonel Drummond adds further information regarding the means of transport, habits of the people (one of the most cultivated of which appears to be thieving), rates for labour, &c.

A sample of ore, which was forwarded last year (1880) by Dr. Aicheson[1] from the Shutargardan, contained 26 per cent. of metallic copper, but was much mixed with silicious matter.

It is somewhat curious that Dr. Lord,[2] who in 1838 described the Ghorband lead mines, was not aware of the occurrence of copper ores near Kabul; he states that all which was brought to him came from Bajaur, north of Peshawar.

Punjab.—Copper deposits in the Punjab are not very numerous, nor do they, so far as our present knowledge of them goes, possess any great importance. The localities where copper ores have been found are situated in the Salt-range, Simla district, Sirmur State, and in Kulu.

Salt-range.—In a group of palæozoic (? silurian) rocks in the Salt-range, to which Mr. Wynne has given the name speckled sandstone, there are certain beds which have been called the copper shales owing to the presence of small nodules of copper sulphide from the size of a pea up to that of a walnut. Dr. Fleming, Mr. Theobald, and Mr. Wynne have all written on the subject. There does not appear to be the slightest chance of the existence of a lode or of a deposit of any kind sufficiently extensive to be of economic value. Mr. Wynne could not find any of the nodules *in situ*.

Simla District: Solan.—There is an abandoned copper mine in the Simla slate series near Solan; nothing appears to have been published regarding it.

Sirmur State: Banal, Lat. 30° 38′ 30″; Long. 79° 29′ 30″.—One mile to the south of the village of Banal there is, according to Mr. R. D. Oldham, an excavation, in which fragments of quartz, forming parts of

[1] Procdgs. As. Soc. Bengal, 1880, p. 4.
[2] Jour. As. Soc. Bengal, Vol. VII, p. 536.

a vein 1 foot thick, lie among the decomposed slates; the quartz is stained with malachite. There are abandoned mines of small extent at Myth in Sirmur and Kalsi in Jaunsar.

Kulu.—Mr. Calvert has brought to light many localities in Kulu where copper ores occur. The principal of these are as follows. There are remains of old copper mines near Chisani and loose blocks from lodes near Maol. At Malanna copper ore occurs with galena but has not been worked. The mountain above Kot Kandi is said to be rich in metallic ores, especially those of copper, the lode being marked by stains of the carbonates. Native copper is reported to have been found in the argentiferous galena mines at Chitrani. Unworked lodes of copper are found in Shatgurh and near Jerri and in the Khanor Khud.

Kashmir.—There are several references to a belief in the existence of copper ores in some parts of Kashmir, but definite information on the subject is wanting. Thus Moorcroft[2] states that mines had been discovered and Jacquemont found copper ore in the Lidar valley, on the south-west side of the range which divides Kashmir from Suru in Ladak. Mr. Lydekker[3] refers to a curious discovery of native copper having taken place in the summer of 1878. Large irregular masses of metal were found in the Zangskar river, but it was not clear whether they had been derived directly from the tertiary rocks close by or from the older rocks further south. General Cunningham[4] pointed out 30 years ago that the name of the district had been derived from *zangs*, which signifies copper, though he could not learn that it had been discovered there.

Copper glance and copper pyrites with metal smelted from them have been received from Rondu, 16 marches beyond Kashmir.[5]

North-west Provinces: Kumaun and Garhwal Districts.—The copper deposits of these districts have long attracted the notice of the Government and the public. They have in consequence formed the subject of a somewhat extensive literature to which both district officials and mining experts have contributed. It will be well to give a brief account of these reports and papers before entering upon the details regarding individual mines.

Captain Herbert's[6] memorandum on the mines and mineral productions of the Himalayas was published in 1829. With reference to the copper localities he gives a considerable amount of information and makes

'Kulu,' pp. 6, 8, 23, 66, 67, 68, 70, 71, 73, 74, 75, 79, 82, 91.
Travels, Vol. I, p. 313.
Records, G. S. I., Vol. XIII, p. 40.
Ladak, p. 234.
Punjab Products, p. 10.
As. Res., Vol. XVIII, p. 239.

some suggestions as to the best method of increasing the outturn from the mines. In 1838 the mines were examined by a Cornish miner, who had been brought out from England by Colonel Drummond.[1] The miner naturally found fault with the wasteful system, or want of system, practised by the miners, and suggested improvements in the tools; enlargement of the narrow burrows into practicable passages; the use of timbering; the introduction of pumping machinery, &c. In 1839 Lieutenant J. Glasfurd published a progress report of the experimental working of a mine at Pokhri. With it there is a plan of proposed adit levels and shafts. The native miners only became reconciled to the use of timbering when in one of the mines they discovered that old timbers had been placed there by their ancestors. A good deal of trouble was experienced in passing the galleries through the ancient workings. In 1841 a final report on this experiment by Mr. Lushington, the Commissioner of Kumaun, detailed the operations conducted under Mr. Wilkins, the above referred to Cornish miner. Between December 1838 and June 1841 a sum of Rs. 3,364, besides Mr. Wilkins' personal salary of Rs. 150 a month, had been expended in the attempt to open up a new mine and two old ones, called respectively the Chowmutti and the Raja's. The result was not considered to be satisfactory and operations ceased. The failure was attributed to poverty and scarcity of the ores and not to any want of skill. Difficult carriage, it was thought, would prevent even a rich deposit from being worked with profit. English copper too, even at Almora, was then selling at a price below that which the native copper brought in the hills, so that the latter could not be expected to compete with the former in the plains. Mr. Lushington, reviewing the whole subject, states that, knowing all the circumstances, he would be sorry to invest money of his own in any enterprise which had for its object the working of these mines.

In 1845 Mr. Siegmond Reckendorf[3], a Mining Engineer, wrote a report in which he sought to controvert the opinions of those who had written before. He claims for the ores a high value, and, with some justice perhaps, states that the means at Mr. Wilkins' disposal were not sufficient to test the deposit fully. He especially condemns the system of smelting which had been practised as being wasteful.

The next report is by Mr. J. O'B. Beckett, dated 1850;[4] it refers principally to the iron of Kumaun, but also gives some information regarding the copper at Lobha.

[1] Jour. As. Soc. Bengal, Vol. VII, p. 934.

[2] *Op. cit.*, Vol. XII, p. 453.

[3] *Op. cit.*, Vol. XIV, p. 471.

[4] Selections from Records, North-Western Provinces Government, Vol. II, Part XII, 1853, p. 67.

In 1855 Mr. William Jory Henwood,[1] with two mining assistants and an iron smelter, came out to report on the metalliferous deposits of Kumaun and Garhwal. Mr. Henwood's report principally deals with the iron, but several pages of it are devoted to the copper ores, with which he does not appear to have been favourably impressed; but he discerned encouraging features at some of the mines.

In 1856 a further report on these mines by Mr. James Barratt, Mr. Henwood's First Assistant, appeared. He recommended that regular mines should be opened at Tomacoti and Dhobri, and speaks highly of the ores.

The latest writers on the subject are Mr. Lawder and Mr. E. T. Atkinson, the account by the latter containing a useful *resumé* of previous information.

RAI MINE.—This mine, which is situated in Gangoli pargana, is, according to Mr. Atkinson, the most important in Kumaun. Mr. Henwood was unable to examine the deposit *in situ* owing to the ruinous condition of the galleries. The matrix of the ore is stated to be a talcose slate with quartz, calc spar and dolomite. The ore itself is chiefly pyrites, which occurs in thin strings, but grey copper also occurs. Colonel Drummond found the cupriferous band to be about 2 feet thick, of which 20 per cent. was ore. Authorities differ as to the true strike and dip of this band. It is traditionally reported that large quantities of metal were produced from this mine, but it is now deserted, and to open it properly would, in Mr. Barratt's opinion, cost more than it would be likely to yield.

SIRA MINES.—The Sira mines are in *patti* Barabisi, in pargana Sira, and are situated on the side of a mountain. The ore is pyrites accompanied by mundic, and it occurs in beds of talcose and calcareous rocks. As blocks of more than a foot cube, which were permeated with veins and spots of ore, had been extracted, it was concluded that the bed was large. The recent writers were unable to obtain access to the interior owing to the galleries having fallen in, but Colonel Drummond found that at 33 fathoms a band of ore was met with in the level, and another at the end of it, neither of them apparently being of much promise.

GAUL MINE.—This mine, which is in *patti* Kharahi, is said to be similarly situated to one called Sor-gurang. Mr. Henwood describes the including rocks as being a white talcose slate and a siliceo-calcareous rock which strike south-east by north-west and dip south-west 35° to 45°. The ores occur in very small quantities; they consist of pyrites, grey copper, and the carbonates; the deposit does not appear to be of much value.

[1] Selections from Records, Government of India, Vol. VIII, 1855.

Mr. Atkinson mentions the following additional localities where traces of copper ores have been observed: Ganai and Phadiali, in *patti* Athgaon, pargana Gangoli; at Bujul and Rathayat in *patti* Bel; and at Tamba Patti in *patti* Gangoli, in a matrix of talcose rocks. There are small mines in *patti* Giwar at Chin-ka-kali, Beler, Sor, and at Kemakhet, on the east bank of the Ladhya river in Kali Kumaun.

"The above-mentioned Gangoli, Sira and Sor mines were farmed from the conquest till 1828, when they were leased for one year to the miners and were again farmed at a reduced rent in 1833. In 1815 they yielded a revenue of Rs. 850, which was increased to Rs. 1,201 in 1819 and 1820, and to Rs. 1,215 in 1821 and 1822; but in 1874 the whole of the copper mines of Kumaun brought in a revenue of only Rs. 30 a year."

The following mines are all situated in the Garhwal district. They are more extensive and are said to have borne a higher reputation than those of Kumaun.

DHANPUR, Lat. 30° 13′; Long. 79° 9′.—The descriptions of the rocks at these different mines vary a good deal. Some speak of the matrix being a dolomite, while others describe it as a silicious limestone which may of course be dolomitic. Occasionally too the term steatite is used for a rock which is probably a talcose schist. The metalliferous zone at Dhanpur is said to be 50 to 60 feet thick, the ores occurring in thin subordinate bands, but, according to Mr. Henwood, there is concentration of ore at the points of intersection of certain joint planes in the limestone with the planes of bedding. A seam of ore one foot thick is mentioned by Mr. Wilkins, but generally it occurs in seams of an inch or less in thickness. The ore found is principally pyrites, but purple and vitreous copper, red oxide, and the carbonates also occur.

The native system of working was to chisel out the thin seams of comparatively soft ore and then to burn the rock so as to facilitate its removal. According to Mr. Atkinson, the mine is not now much worked by the natives, partly owing to the intricacy of the passages and partly in consequence of the belief that it is nearly exhausted.

DHOBRI, Lat. 30° 12′ 30″; Long. 79° 7′ 39″.—This mine is situated on the south side of the Dhanpur range, and according to some of the authorities it is considered that the deposit is continuous with the one last described, the including rocks being identical, or nearly so, in character.

Mr. Barratt gives a full description of one of the mines near the village, which was the only one open. The incline dipped with the ore from the outcrop on the mountain side at an angle of 10° south-south-west. The seam of ore, for it does not appear to be a true lode, was 2 feet thick and was rich in copper pyrites and purple copper; the air at the

bottom of the incline or drift was so foul that the men could only stay in it for a few minutes; six men worked in turns, five breathing fresh air outside while one was inside in the dark, as no light would burn in the vitiated atmosphere. The pyrites is said to contain 25 per cent. of copper. Mr. Barratt was of opinion that this mine with proper system could be worked profitably. Copper was then selling at Rs. 2 a seer, or at the rate of £224 per ton.

To the west of the village there are several deserted mines, the custom of the miners having been to open a new mine on the outcrop when the passages in the old ones became too intricate. There is water power suitable for machinery 1½ miles below the mine, and an abundant supply of wood for all purposes.

AGAR SERA.—At this locality, which is in the *patti* Lobha and at Tomacotee, 3 miles north-north-west of Agar, there are old mines which appear to be not much worked owing to their depth and the badness of the ventilation. Mr. Henwood thought that the thin strings of vitreous and purple copper traversing the quartz, though not constituting a rich ore, offered some encouraging features. Improvements in the mines were suggested by Mr. Barratt, but the adits required could not be cut in the hard rock except at great expense. He states that the Tomacotee mine is favourably situated, wood and water being abundant, and the Ramgunga might be made use of to afford power to pump mines below the base of the mountain.

POKHRI, Lat. 30° 20′; Long. 79° 15′.—This locality is in the centre of a group of mines bearing the following names: Chaumattiya, Raja's, Nota, Thala, Danda, Talapungla, and Kharna. The first three were the scene of the experimental mining carried out by Government under Mr. Wilkins, which has been described above. These mines were worked in early periods by the Garhwal Rajas and subsequently by the Gurkhas. Some of the mines offer considerable facilities for working; in others there would be difficulty in establishing effective drainage; in some, the ores are said to be rich. Mr. Henwood's report[1] on the Chaumattiya mine, more clearly than those by any of the other authorities, indicates the mode of occurrence, and is in part applicable to all the mines throughout Kumaun and Garhwal. He says: "There is no *lode* or metalliferous *vein* visible in it, nor have we seen one during our enquiries in this country. The copper ores extracted lie in thin plates between the laminæ of the slate rock, which bear about 20° west of north (magnetic), and dip north of east, 50°. The formation exposed in

[1] Selections from Records, Government of India, 1855, Vol. VIII, p. 4.

the deeper part of the gallery is a fissile homogeneous lead blue slate, which closely resembles the Killas of some parts of Cornwall, and the metalliferous slates of Wicklow; on this reposes an equally thinly laminated rock of a pale yellowish buff colour, which seems almost exclusively composed of talc; extremely thin short beds of quartz occur conformably at intervals between the slaty laminæ, occasionally tinged with earthy brown iron ore. Copper pyrites and purple copper ore, in plates equally as thin as those of quartz, but perhaps rather longer and broader, are in like manner interstratified amongst the rocks, possibly rather more abundantly near their junction than elsewhere. Where they touch the quartz they transfuse it, and the united mass for an inch or two increases in size, but it as rapidly dwindles and they soon separate. They seldom exceed half an inch in thickness, the metallic, equally with the earthy ingredients evidently being part of the rock formation, which is copiously stained with the green and occasionally with the blue carbonates of copper."

Regarding the Raja's mine, which however had fallen in at the time of his visit and was inaccessible, Mr. Henwood remarks: "We have never before seen a spot so scantily sprinkled with ore, and offering in our judgment so small a prospect of improvement, so extensively and perseveringly worked."

It would seem from a perusal of all the numerous reports that these copper deposits of Kumaun and Garhwal are not such as to offer a very encouraging prospect for the investment of capital.

Mr. Henwood's acquirements give to his opinions a much higher value than can be attributed to those of some of the other writers. He states that of the reports which had been written before his visit, Mr. Lushington's was by far the most minute and practical.

In reference to the high price of copper in the hills it should be borne in mind that this would probably be reduced by a large outturn, and the demand being limited, another market would have to be found for it.

The native process of smelting the ore being substantially the same as that in practice in Sikkim, and which is described below, need not be specially noticed here.

Nepal.—The existence of mines of copper in Nepal has long been known, but beyond the bare fact there is no information whatever owing to the jealous way in which the resources of that country are kept hidden from the public. In 1833[1] Mr. B. Hodgson presented some samples of copper pyrites largely mixed with mundic from Nepal to the Asiatic

[1] Jour. As. Soc. Bengal, Vol. II, p. 95.

Society. Dr. Campbell,[1] when announcing the discovery of copper ores in the Darjiling district, alludes to those of Dunkoota, in Nepal, as being rich; and Captain James also refers to the excellence of samples of Nepal ores. In the year 1854 Jung Bahadur presented some samples of ore to the Asiatic Society, and Mr. Piddington, observing that these included pieces of a curious mineral worthy of special investigation, applied for further samples which were ultimately obtained for him by Major Ramsay.

Mr. Piddington[2] describes the matrix of the ore as consisting of different varieties of quartz, all beautifully stained with the turquoise blue of the copper which the ore contains, and the matrix is varied by nests, layers, and plates of a bright fawn-red ore, which is a silicate of cerium and iron; altogether it is one of the most beautiful and showy of minerals. The ore itself is massive and uncrystallised and occurs in veins from six-eighths to one-eighth of an inch or smaller. In external appearance it resembles some of the varieties of graphite ore the ores of antimony for which, where the enveloping quartz has no blue stain, it might be mistaken. The Nepalese having smelted some of it cast it into cannon balls which when fired flew into pieces.

Mr. Piddington's analysis of the ore, if it could be relied on, shows that it had a very complex composition, and he proposed for it the name Nepaulite. The constituents were stated to be as follows—

Sulphur	1·60		
Silica	3·60		
Bismuth Carbonate	34·80	28·5	Metal.
Copper "	22·96	14·40	
Iron "	25·62	9·21	
Cerium oxide	9·40		
Lanthanum ?	2·80		
Total	100·78		

As has been remarked in Chapter III, the ore apparently contains a large percentage of bismuth.

Mr. Medlicott,[3] when he visited Nepal in 1875, was not permitted to examine the copper mines, which he believed to be situated on a faulted or disturbed line of junction between the gneiss and some quartzite schists. By a curious coincidence, when passing along the road near this place he met a number of coolies carrying copper which was being

[1] Jour. As. Soc., Bengal, Vol. XXIII, p. 207.

[2] *Idem*, p. 170.

[3] Records, G. S. I., Vol. VIII, p. 96.

imported from India, and hence he concludes that the native resources in the metal cannot be very great at present; but there were abundant heaps of refuse from old copper smeltings.

Darjiling District.—The existence of copper ores in the Darjiling district and its neighbourhood was first discovered in 1854 by a Nepalese in the service of Dr. Campbell. This man had been accustomed to the appearance of the ores of copper from having seen them worked in Nepal. Dr. Campbell[1] at once took steps to prove the deposit, and samples were forwarded to Mr. Piddington for assay. The claim of the Government to all ore found, was announced in accordance with the rules issued when the territory was ceded to the British in 1839. In 1856, the mines which had been opened were visited by Mr. Taylor, a practical miner, whose report was unfavourable to the possibility of their being worked with profit. In the year 1874, during the course of his geological survey, Mr. Mallet[2] examined all the known localities where copper had been found. The following is an abstract from his published report. His classification of them, according to their condition when visited by him, was: Mine now worked, Mangphu; mines abandoned but still partially open, Rani Hat, Pashok (1), Kalingpung; mines abandoned, Mahanadi, Pashok (2), ravine west of Chel river, Chel river; trial openings, Pankabari, Rani Hat, Mangwa, Re Ung; recently discovered and not opened up, Rangbong, Sampthar.

The ores at all the above localities occur in rocks of the Daling series, or in the transition rocks between them and the gneiss, but none are in the gneiss itself. In all cases the ore is copper pyrites associated with mundic or iron pyrites. Traces of the sulphate, carbonates, and oxides of copper occur as the result of the alteration of the sulphide. The ore does not occur in true lodes but is disseminated in the schists and slates.

Rani Hat. (1)—In the bank of the Rani naddi, a mile above Rani hât, two excavations have been made, where there was a small quantity of pyrites with traces of copper.

Rani Hat. (2)—A mile north of and 1,100 feet above Rani hat, the ore occurs in quartz and hornblendic schist in thin and scattered layers, through a stratum of about 18 inches in thickness; the dip is 65° to north. There were six galleries visible, but five of them had fallen in; the mine was free from water owing to its steep position. It had been worked for a short time in 1873.

Mahanadi.—On the west side of the Mahanadi, near the north of

[1] Jour. As. Soc. Bengal, Vol. XXIII, pp. 206 and 477; and Vol. XXIV, p.p. 251 and 707.

[2] Mem., G. S. I., Vol. XI, p. 72.

the Baffupani, the ore occurs in a stratum, 2 feet thick, the gangue being hornblende schist with quartz, and dipping 30° to 40° to west; associated with the pyrites there is some zinc blende. There had been several openings here, but they were abandoned and had fallen in. Mr. Mallet considers that the ores at this locality and Rani hat may be on the same horizon, and that there were probably workings at intermediate spots, but he could obtain no local information about them.

Pashok.—The principal mine is on the hill side above the Rangiak stream. It has been worked by different proprietors. The copper bearing rock is similar in character and is considered to be on the same horizon as that at the previously mentioned localities. A sample of ore forwarded by Dr. Campbell to Mr. Piddington yielded only 1¾ per cent. of copper. Another mine here has fallen in.

Rangbong.—Copper ore is reported to have been found here.

Kalingpung.—The mine is two miles north-east of Kalingpung. The rock is clay slate with bands of quartzite and little seams of quartz. The ore occurs in all, but principally in the quartz. The mine was worked about the year 1871 or 1872, but was given up on account of the hardness of the rock. The largest opening runs for 40 feet along the strike, and is 10 to 12 feet deep.

Re Ung.—A trial drift was made about a quarter of a mile from the mouth of the Re Ung. The rock is clay slate with bands of quartzite; dip 40° to north 30° east. The ore is sparsely distributed in the rock and the drift had been abandoned.

Mangphu.—This mine is on the Tista; it was opened about the year 1870 and is considered to be the best in the Darjiling district. It was the only one being worked at the time of Mr. Mallet's visit. The rock is a light green slate, containing irregular layers of fine slaty sandstone; the dip is to from 30° to 40° to north-east. The ore, with which there is little or no mundic, occurs in both rocks in lenticular layers. The main inclines in the mines descend with the dip to a depth of 46 feet; they were dry in January. The cupriferous layers occur at intervals throughout a total thickness of 200 feet, and there have been openings into these at various levels.

The lessee stated that the yield of copper from the picked ore is 4 per cent., and that during a year he had made 72 maunds of copper, *i. e.* upwards of two and a half tons.

Sampthar.—In a lateral ravine which joins the Lesu south of Sampthar indications of copper have been exposed by a landslip. The mode of occurrence and character of the ore is similar to that last described, but the extent of the deposit is not known.

West of Chel river.—A small quantity of ore was extracted from the slates in a ravine west of the Chel river. The band of ore was only one or two inches thick and the dip was north at 40°.

Chel river.—This mine was unfavourably situated, being in the bed of the river. The seam or band of ore was from 4 inches to a foot in thickness, and the slate including it dipped east of north at 30°. The mine was difficult to work on account of sickness, and was given up in consequence of the death of a number of the workmen.

Sikkim: Rattu.—This mine is in Independent Sikkim. The rock is clay slate with lenticular bands of quartz; the dip is high, approximating to the vertical. Mr. Mallet says the ore is the best he had seen; it is free from mundic and occurs in considerable quantity. A selected sample gave 9·1 per cent. of copper, and an ordinary one from a heap prepared for washing gave 7·8 per cent.

Bhutan: Chamurchi.—Copper ore is said to occur in the river near this locality; some Nepalese who attempted to work it were driven away by sickness. Mr. Mallet found a piece of quartzite containing copper ore in the bed of the river.

Western Duars: Buxa.—Mr. Mallet alludes to a discovery of copper ore in a greenish slate with quartzose layers at a spot half a mile west of Buxa. The proportion of mundic at the surface was greater than that of the ore. Since his visit samples of copper ore from several places in this neighbourhood have been forwarded to the Geological Survey for examination and report. One specimen of bornite or purple copper ore, containing about 60 per cent. of metallic copper, was received; this, if obtainable in quantity, would of course be highly valuable, but no evidence as to its abundance is yet available. This specimen appears to have been from the locality to the west of Buxa, but there is said to be another on the east (Official Correspondence, 1875-76).

Mining and smelting, whether in Sikkim or Bhutan, seem to be exclusively in the hands of the Nepalese. The processes employed have been described by Mr. H. F. Blanford[1] and by Mr. Mallet. The latter compares the mines to magnified rabbit holes; props to support the roof are only occasionally made use of, and the passages meander with the courses of the ore, and do not exceed a yard square diminishing downwards in the narrowest parts to half this dimension. The tools used are an iron hammer, a gad or chisel held in a split bamboo, and a pick. The light is afforded by thin slips of bamboo, the smoke from which in the confined passages is not so irritating to the eyes as that from other kinds

[1] Percy's Metallurgy, p. 387.

of wood. The ore is carried out in narrow baskets, and picked, crushed and finally pounded with a stone hammer or pounder fixed in a forked stick. It is then subjected to several washings, ground in a hand-mill, rewashed, and is at last ready for the preliminary smelting.

The furnace is either built of refractory clay, or is simply a hole dug in the ground with a clay rim at the sides and front, and a higher one or a stone at the back; the inside is plastered with refractory clay if it is not sufficiently so naturally. The furnace is 18 inches deep, a foot square at top, and tapering to the bottom, where charcoal is rammed down so as to form a floor through which the molten metal cannot sink. There is no orifice at the base of the furnace. Two clay tuyeres dip into it vertically and are connected with simple skin bellows by horizontal tuyeres, which are about a yard long. The furnace when filled with lighted charcoal is soon raised to its full heat by the alternate working of the bellows, and the ore is then sprinkled on from time to time until a sufficient quantity of regulus, covered by lighter slag, has collected at the bottom. On the removal of the charcoal the surface of the slag is cooled with a whisp of wet straw, and several cooled and solidified cakes of slag are removed in succession, leaving the heavy regulus behind, which when set is taken out, pounded, and kneaded with cowdung into balls; these are dried in the sun and then roasted with free access of air in a shallow furnace formed of a ring of slag cakes placed on edge. The last process or refining consists in treating the powder produced from these roasted balls in the same furnace, and in precisely the same manner as was the original ore, the result being that a fluid mass of copper is found at the bottom of the furnace which on cooling is removed. In this state it is sold at a rate equal to about 10*d.* a pound, but it has to be still further refined before it is available for ordinary purposes. The lessee of the Mangphu mine informed Mr. Mallet that the yield from the various operations was as follows, but the figures may not be quite reliable: One maund picked ore = 6 or 7 seers of washed ore; 7 seers of which = 4 of regulus; 4 seers of regulus = 1¾ seers of copper, or 3¾ to 4½ per cent. of copper from the picked ore. Eight or nine seers of regulus are obtained at one operation in about six hours, and 3 or 4 seers of copper in about three hours more.

Assam.—In Assam proper no ores of copper have as yet been discovered. According to Mr. Robinson a small quantity of smelted copper used to be brought into Assam from the Abor country to the north-east, but the visits of the Abors used not to be much encouraged. It is not improbable that the deposit of ore, from which this copper was made, is of the same character as that found in Sikkim.

In the year 1879 Colonel Johnstone, Political Agent at Manipur, forwarded some copper ores from the low hills bordering the Kubo valley in Manipur. The samples were examined by Mr. Mallet, who found that they consisted of a mixture of the carbonate (malachite) silicate (chrysocolla) and sulphide of copper associated with cupreous hæmatite. The contained metallic copper amounted to 18·1 and the iron to 44·3 per cent. Nothing is at present known as to the extent of this deposit.

Burma: Arakan Division.—Nearly forty years ago some excitement was caused by an alleged discovery of copper ores on Round Island, off the coast of Arakan. The specimens which gave rise to the story were forwarded by Captain Williams to Mr. Piddington,[1] who described them as "nodules of native copper with red and black oxide and silicate of copper," and in another account the "blue and green carbonates" were substituted for the silicate. Mr. S. Morny also gave an analysis, stating that the specimens consisted of an alloy of copper, titanium, mercury, lead, cobalt, and iron. The Rev. F. Mason[2] states that he saw a specimen of azurite or the blue carbonate of copper from Cheduba.[3]

In the year 1878 Mr. Mallet visited Round Island, which he found, as he had anticipated, was made of stratified tertiary rocks similar to those of Ramri and Cheduba, and therefore very unlikely to be the matrix of copper ores. No one on the island had heard of copper ores having ever been found. So the matter might have rested had not Mr. Mallet found a tray of pellets of metal in the old collection of specimens in the Museum which were labelled "Copper ore from Flat Island," presented by Captain Williams. It was obvious from the original papers that there had been confusion between the names of the two neighbouring islands. On examination these pellets proved to consist of an alloy of copper and tin, and one which has never been found native, but which is commonly made artificially and used by the Burmese. It is clear therefore that the pellets were not of natural origin. From their condition when found they had probably long been buried. The alteration of metallic copper and bronze when long buried in certain soils is well known to take place.

Tenasserim.—ROWN-ZA-LENG OR YONZALIN OR YOONZALEM RIVER. A specimen of copper ore from a spot on this river, said to be accessible by boats, was obtained by Mr. O'Riley in the year 1863, and was forwarded to Mr. Waldie for analysis.[4] It proved to be a very singular and appa-

[1] Jour. As. Soc. Bengal, Vol. XII, pp. 303, 904, 914, 1014.

[2] Natural Productions of British Burma, p. 39.

[3] Records, G. S. I., Vol. XI., p, 222.

[4] Proceedings, As. Soc., Bengal, 1870. p. 279.

rently hitherto undescribed combination of minerals, and Mr. Waldie named it after its discoverer, O'Rileyite.

The following are the results of the examination of two specimens which indicate that the substance is not a definite compound. The second specimen appears to have been from a distinct locality—

Copper	17·000	12·13
Silver	·096	...
Iron	36·470	42·12
Arsenic	32·700	38·45
Antimony	1·150	·54
Sulphur	1·360	...
Oxide of copper	...	1·21
Oxide of lead	...	1·89
Arsenious acid	...	1·12
Protoxide of iron	...	1·97
Earthy matter	·560	·12
Loss	10·664	·45
	100·000	100·000

The proportion of silver in the first assay is equal to 31·3 ounces troy to the ton of ore, but in the second no trace of silver is indicated. Dr. Waldie, in consequence of the absence of sulphur in the second and its small quantity in the first, and the fact that the proportions of constituents cannot be reduced to any probable formula, was inclined to regard the mineral as an alloy. Nothing is yet known as to its abundance or precise mode of occurrence.

Four other samples of copper ores were obtained by Mr. O'Riley, three of them in different localities with the galena of Martaban and one in the hills east of the Sittang river.

Mr. O'Riley [1] also obtained copper slags and metallic copper at three localities between Maulmain and the mouth of the Tavoy river. According to Dr. Oldham, who reported on these specimens, one of the fragments of metallic copper had been part of a manufactured vessel; the other was too small to allow any opinion being formed regarding it, but the scoriæ seemed to point to the existence of a source of ore in the neighbourhood.

In the year 1873 Mr. M. Fryar [2] visited a locality where copper ore occurs, on the Megathat, a tributary of the Attaran, several days' journey to the south-east of Maulmain. The ore, so far as he was able to see,

[1] Records, Bengal Government, No. VI, pp. 27 and 33.

[2] Letter to Commissioner of Tenasserim, dated 26th July 1873.

had been brought in solution and deposited among detritus between two hills, and in this detritus drifts had been made by the natives, naturally without success; no vein or lode of ore was discovered.

According to Captain Foley, as quoted by Mr. Theobald,[1] stains of the copper carbonates occur in the Botoung hills, 90 miles north-north-east of Maulmain.

There are rumours of the occurrence of copper ores in some of the islands of the Mergui Archipelago, Lampei or Sullivan's Island being specially mentioned, but there is probably no good foundation for these rumours. Altogether it must be stated that at present, taking into consideration all the available information, there is no solid ground for hope that copper in workable quantity will be found in British Burma.

Upper Burma.—According to Dr. Oldham[2] the copper required at Amarapura in 1855 was all brought from China; it amounted to about 35,000 viss (=about 57 tons) per annum. Copper ores were said, however, to be abundant in the Shan States, and a rich deposit, 80 miles from the capital, is specially mentioned. Dr. John Anderson[3] states that copper is brought into Momein from a range of hills near Khyto, and he considers that it might possibly become, with other metals, a regular export. In 1873 the supposed rich deposits of copper in the Shan States were still unworked. Major Strover[4] states that there is a rich description of malachite at Bawyine and Kollenmyo. Copper mines at Sagaing had been worked by the Chinese but were then abandoned. Ores of copper are believed to be plentiful in Yunan.

It is noteworthy that there is, or used to be, a small export trade in copper from the port of Rangoon, the metal being in the form of broken or used-up copper vessels which had doubtless been originally brought from China or the Shan States.

[1] Records, G. S. I., Vol. VI, p. 94.
[2] Colonel Yule's Mission to Ava, p. 346.
[3] Expedition to Yunan *viâ* Bamo, p.p. 92, 333.
[4] Gazette of India, reprinted in Indian Economist, Vol. V, p. 14.

CHAPTER VI.

LEAD.

LEAD—General Remarks. *Madras* — Kadapah — Karnul — Palnad — Bellary. *Bengal*— Bhagulpore — Monghyr — Chutia Nagpur — Manbhum — Hazaribagh — Lohardaga — Sirguja. *Central Provinces*—Sambalpur — Raipur — Jabalpur — Hoshangabad — Nagpur — Rewah and Bundelkhand — Rajputana — Ajmir — Ulwar — Udepur. *Bombay, Extra-peninsular*—Balochistan—Afghanistan. *Punjab*—Hazara—Mari — Simla —Sirmur — Kulu. *North-Western Provinces*—Garhwal — Kumaun — Nepal — Darjiling — Assam — Burma.

Lead: General Remarks.—Lead rarely occurs in the metallic state or native, and there appears to be no recorded case of its ever having been found in this condition in India. Its commonest ore is the sulphide or galena; many of the other ores are chiefly of interest to the mineralogist, but bournonite or antimonial lead, cerussite or the carbonate, pyromorphite or phosphate, mimetite or arsenate, and crocoisite or chromate, are all of economic importance. Many of the compounds of lead which do not occur abundantly in nature, but which are extensively used in the Arts for pigments, dyeing, glass-making, medicine, &c., are artificially prepared.

Although at the present moment there are no lead ores largely worked in India, there is probably no metal of which the ores have been formerly worked to so large an extent, excepting of course those of iron. This is testified to by the extent of the ancient mines in Southern India, Rajputana, Balochistan, and Afghanistan. In some of these cases the ore may have chiefly been sought for for the silver which it included.

In peninsular India the ores of lead are found in the rocks of metamorphic, submetamorphic, and lower Vindhyan ages only; but in the extra-peninsular areas they occur in at least one younger formation, namely in the cretaceous rocks of Balochistan.

Madras.—In the Madras Presidency lead ores have been found in the following districts: In Kadapah, at Jungumrazpilly and Cotelur; in Karnul, at Gazalpully and Koilkontla; in Bellary, in the Sandur hills; in Palnad, at Karampudi. All these deposits, save that at Bellary, occur in rocks belonging to some one or other sub-divisions of the Karnul series.

Kadapah District: JUNGAMRAZPILLY OR BASWAPUR; Lat. 14° 46′ 30″; Long. 78° 56′ 30″.—At first sight there is not a little confusion in the accounts of the lead mines in the Karnul and Kadapah

districts, owing to the fact that the name Baswapur is applied by different authors to wholly different places. The Baswapur of Wall is close to Jungumrazpilly in Kadapah, while the Baswapur of Newbold[1] and King is a well-known locality in Karnul, close to which is a village called Gazalpully. As a further source of confusion no two of the above-named authors spell these names in the same way, or as they are spelt on the map; each village appears to be provided with a varied assortment of *aliases*.

The village of Jungumrazpilly is situated on a pass which traverses the range of hills known as the Nallamallays, about 4 miles north of the road from Kadapah to Budvail. Mr. King's[2] account partly drawn up from Mr. Oldham's notes, partly from personal observations, is as follows: "The old and now deserted lead workings are at the south end and east side of the low ridge, just north-north-east of the village. The pits or galleries have been excavated between beds of dark grey silicious limestone, which is impregnated with strings of white and dull blue quartz. These rocks are referred to the Cumbum division of the Nallamallay group of the Karnul series. Granular sulphide of lead is disseminated in very small quantities through the blue quartz. In the white quartz there are faint traces of copper. The strings of quartz have been deposited in north-north-east and south-south-west fissures, having a dip of 60° westwards, the strata lying at 50° to east by north. The old workings are to a great extent filled up with the excavated fragments of rock and are now overgrown with jungle."

Further south and west of Jungumrazpilly there are again numerous old galleries excavated in the same series of beds; these were found to contain traces of galena, which appeared to be more abundant in the bedded rocks than in the veins traversing them, but most of the ore had been removed.

East of the same village there is a zone of similar rocks traversed by quartz veins, striking north-north-east in which copper ores, pyrites, and carbonates occur. The continuity of this zone is disturbed by cross-faults. At Raiculcoonta it ceases.

Captain Newbold described[3] having descended a considerable depth into one of a group of upwards of 50 mines, which are situated to the south of the abovementioned road. Some of the masses of rock exhibited signs of blasting! Other excavations, mentioned by Captain Newbold, are within a radius of 15 miles of the above area, at Kundela-

[1] Newbold, however, mentions 'Bussapur' in his account of Jungumrazpilly.

[2] Mem., G. S. I., Vol. VIII, p. 273.

[3] Jour., Roy. As. Socy., Vol. VII, 1843, p. 217.

Bori and Polleram Manu. Mr. King also alludes to some situated to the west of Jungumrazpilly, opposite Wonypenta, and at the entrance of the Ghingroy Convoy.

Mr. Wall, Mineral Viewer to the Government, describes this locality in two reports to Government;[1] unfortunately a plate which he refers to, as showing the course of the lead vein, does not appear to have been reproduced. He mentions the extension of the lode at points further south than do the other already quoted authorities. To the west of the main lode, and at a distance of three-fourths of a mile from it, what he calls a branch vein occurs south-east of the village of Nagsanpilly; it is split into two portions, 2 feet apart, each averaging 4 inches thick; they are, however, rich in galena, and copper ore occurs with it. The main lode extends into the Lunkamalla hills. Mr. Wall's analysis of these ores are as follows, he having made two of each :—

					Oz.	Dwt.
Jungumrazpilly	1.	Lead per cent.	66·614	Silver per ton	10	14
	2.	" "	69·664	" "	13	13
Do. slime	1.	" "	22·407			
	2.	" "	33·992			
Lunkamalla	1.	" "	70·121	" "	9	2
	2.	" "	76·371	" "	8	4
Do. slime	1.	" "	36·278	" "	8	4
	2.	" "	46·000	" "	8	4

A sample of ore assayed by Mr. Mallet in 1879 yielded 78 per cent. of lead, and 22 oz. 7 dwts. of silver to the ton of lead.

It is almost certain that Dr. Heyne's statement, Tracts (p. 316), that some ore from a mine 8 miles from Kadapah, which was assayed in Bengal by the Assay Master and was found to contain 11 *per cent.* of silver, must have been a mistake, since 11 per cent. would mean 246·4 lbs. to the ton of ore. This mine was, he says, worked by Tipu Sultan, but was abandoned on account of its not being sufficiently rich.

It is impossible to read the above account without being impressed with the evidence afforded of this being a metalliferous locality of much promise, the value of which has been much enhanced, as Mr. King points out, since Mr. Wall's time by the proximity of the North-Western line of railway.

According to Captain Newbold (*l.c.*) the origin of the extensive excavations in this tract is lost in obscurity. It is known that the mines were worked in the time of the Hindu kings of Bijanagar, and subsequently by the Mahomedan nawabs of Kadapah in the time of Halim Khan, and

[1] Madras Jour. of Lit. and Sci., Vol. XX, 1858-59, pp. 279 and 289.

afterwards by Hyder and Tipu; the latter is said to have destroyed all the mining records! The excavations which exhibit marks of blasting were, he thinks, probably worked by Mahomedans, who employed gunpowder at a very early period in quarrying rocks. Captain Newbold adds, however, that about 30 years previously, which would be about the year 1810, an officer of the Madras Engineers commenced work, but after a short time gave it up again.

The possibility of the silver mines alluded to by Pliny having been in this region has already been referred to in Chapter IV.

COTELUR, Lat. 14° 36′ 30″; Long. 78° 48′ 15″.—Captain Newbold refers to a report that galena was found in a hill near the Pennair river, not far from Kadapah, and suggests that the metalliferous zone extends northwards to the Kistna and southwards to the Pennair. That the report was well founded is proved by the fact that Mr. Wall [1] describes the occurrence of a vein of quartz, containing cubical crystals of galena at Cotelur, and striking across the river from north-north-east to south-south-west. He is uncertain as to its identity with the Lunkamulla lode, above alluded to. It traverses a bed of limestone locally known as *poospagherry* stone.

Karnul District: GAZALPULLY OR BASWAPUR, Lat. 15° 26′; Long. 78° 45′.—Captain Newbold [2] in 1846 described the mines in the vicinity of these villages. They were situated about 6 miles east of Gazalpully (or Gazoopilly). The galena, in association with sulphate of baryta, occurs in veins of quartz. Several other minerals are also present, the most notable being a faint reddish coloured one, which Mr. Piddington identified as carbonate of cerium; [3] another mineral he named Newboldite, finding it to be a sulphuret of iron and an unknown earth. These excavations were numerous and were from 5 to 15 feet deep. The diamond mines are closer to the villages.

Mr. Wall's account [4] of this locality represents it as affording favourable indications. In two samples the metallic lead averaged 57·5 per cent., and silver was present in the proportion of 5 oz. 19 dwts. to the ton.

Mr. King describes [5] the deposit of sulphate of baryta, which is full of strings of granular and massive galena, as occurring in the same way as at Jungumrazpilly, in the north-north-east and south-south-west

[1] Madras Jour., Lit. and Sci., Vol. XX, p. 280.
[2] Jour. As. Soc. Bengal, Vol. XV, p. 389.
[3] *Idem*, p. 52, and Vol. XVI, p. 1134.
[4] Madras Jour., Lit. and Sci., Vol. XX (new series, 4), p. 286.
[5] Mem., G. S. I., Vol. VIII, p. 278.

fissures of jointing in siliceo-calcareous beds of the same slate series. A broad deep trench or quarry cut in these rocks is supposed to have been the work of the Moguls.

KOILKONTLA, Lat. 15° 14′; Long. 78° 23′.—Under the name Coilcontla, 6 miles west of Dhone, in Karnul, which it is to be presumed is identical with the Koilkontla of the map, Mr. Wall (*l.c.*) described another mine, the actual site being one-fourth of a mile south of the village. He stated that it is situated amidst hills of granite and other primitive rocks. There are, however, no primitive rocks nor even hills at the locality indicated. The rocks belong to the Khoondair group of the Karnul series, according to the Geological Survey map. The ore occurs disseminated through a hard siliceous matrix, which would require to be crushed. This would make it more expensive to work than the last-mentioned ore. Forty maunds of this ore, sent by Captain Russell, were examined at the Mint, and, together with samples collected by Mr. Wall himself, indicated an average yield of 12 to 14 ounces of silver in a ton of the lead. Previous assays by Dr. Scott gave 70 per cent. of metallic lead from the dressed ore. Mr. Wall refers to the prospect of the railway rendering it possible to have this ore carried to some locality where fuel is abundant.

Dr. Balfour [1] gives an account of ores, apparently from the same locality, which were exhibited in Madras in 1857. He speaks of samples 18 inches in diameter and weighing upwards of 3 cwts. The ore is said to have been discovered accidentally by the late ex-Nawab of Karnul when digging a well. Although Dr. Scott's first analysis showed no silver, after re-examination the ore was said to contain upwards of 1 per cent. or 374 ounces to the ton. Other analyses of specimens from Karnul yielded respectively 175 oz. 3 dwts. and 165·15 dwts. in the ton of lead, as already stated in the Chapter on Silver. But as these results are exceptional, being quite unprecedented in India, they require confirmation before they receive implicit acceptance.

Palnad District: KARAMPUDI, Lat. 16° 26′; Long. 79° 47′.—Mr. King [2] mentions that there are old lead mines at the north-eastern extremity of the Wanmyconda range, near the village of Karampudi, in the Palnad, a district on the Kistna, west of Guntur.

The mines are in grey siliceous limestones belonging to the Karnul series.

Bellary District: SANDUR HILLS.—According to the Bellary Dis-manual, trict (p. 95), lead has been found in the above-named hills.

[1] Cyclopædia, Art.—Galena.

[2] Mem., G. S. I., Vol. VIII, p. 271.

The so-called antimony,[1] found near Vizianagram, is also possibly galena.

Before leaving the subject of South India lead ores it may be of interest to quote an old analysis by Dr. Thomson[2] of a supposed new species of lead ore procured in the shops at Madras by Dr. Heyne, who believed that it originally came from Malacca and Sumatra. It was employed medicinally.

Externally the mineral was blackish blue with green stains here and there. Internally, when broken, it resembled galena, but was somewhat darker. Dr. Thomson considered it to be a chemical compound of the sulphides of iron, lead, and copper, and not a mechanical mixture. He suggests the possibility of its being of artificial origin. The result of his analysis proved that it contained—

Lead sulphide	57·269
Copper „	40·850
Iron „	·2·190
Total . .	100·309

Bengal: Bhagalpur Division.—Within the limits of the Bhagalpur Division lead ores, principally argentiferous galena, have been found in the Sontal Parganas district at or near the following localities: Sankera Hills, Turee (? Tiur) Hill, Bairuki, and at Panch-pahar, or Akasee.

In the Bhagalpur district the occurrence of lead ores is recorded from Gouripur or Phaga (also known as Lachmepur), Dudi Jor, Karda, Gonora, Kejurea, and Khureekar.

In the Monghyr district, in or near the Kharakpur hills, and in the Chakai pargana, there are rumours of lead ores having been found.

The Institutes of Menu are said to refer to the region in the vicinity of the Mandar Hill as being rich in mineral wealth. By some authorities it is thought that the terms Chandu, Chandun, &c., which occur as names of certain hills and rivers, may have reference to an early knowledge of the fact that silver (*chand*) occurred in the lead ores.

Throughout the division, except perhaps in the doubtful Kharakpur locality, these deposits all occur in the older crystalline or metamorphic rocks.

Sontal Parganas District: Sankera Hills, Lat. 24° 18′; Long. 87° 22′ 30″.—In these hills, which are about 5 miles to the north-east of the station of Nya Dumka, Captain Sherwill, who calls them the Singhee-

[1] Vizagapatam District Manual, p. 155.

[2] Memoirs of the Wernerian Natural History Society, Edinburgh, Vol. II, 1818, p. 252.

math hills, indicates on his map that galena had been found. The rocks belong to the general metamorphic series, a trap dyke traversing them from north to south. The exact spot is not known; possibly it was in the Chandrapahar (or silver hill) to the south-west of the main mass of the Sankera hills.

TUREE PAHAR.—According to Dr. McClelland[1] galena was obtained at a place bearing the above name; possibly it is intended for Tiur, lat. 24° 30′; long. 86° 54′.

BAIRUKI, Lat. 24° 35′ 30″; Long. 86° 40′ 15″.—In the Chapter on Copper this locality has already been described. The copper ores occur there in greater abundance than do those of lead, so far as is at present known.

Mr. Piddington[2] describes the samples forwarded to him as consisting of (1) bright large-grained galenas, and (2) cupro-plumbite, an ore of copper and lead in diagonally lamellar veins; neither of these yielded any silver to Mr. Piddington's analysis, though the copper ores did.

Mr. Barratt[3] describes the lead deposit as being situated 60 fathoms to the south of the copper. A true lode had not been found, but lumps of lead ore, several of them consisting of pure galena, 20 pounds weight, were taken from a bed of quartzite, which strikes with the rocks generally from east to west.

Messrs. Johnson and Mathey assayed some of this galena with the following result—

Lead	82·25
Silver	·09
Sulphur	15·40
Carbonic acid	·86
Silica	1·40
Total	100·00

The proportion of silver = 29·4 oz. to the ton of ore; it contains a very slight trace of gold. A ton of the smelted lead therefore would contain 35 oz. 14 dwts. of silver.

PANCH PAHAR OR AKASEE, Lat. 24° 38′; Long. 87° 15′.—Close to the village of Akasee, in the Passye pargana, the presence of lead ore is indicated on the Revenue Survey map by Captain Sherwill; and

[1] Report on the Geological Survey of India, p. 32.

[2] Jour. As. Soc. Bengal, Vol. XX, p. 7.

[3] Report to Messrs. Mackey and Co., Calcutta, dated Birbhum Iron Works, December 1856, p. 8.

Dr. McClelland says that it occurs in a decomposing bed of coarse granular quartz, glassy actinolite, or, as suggested by Mr. Dodd, perhaps coccolite and earthy felspar.

The galena, in small crystals, constitutes, it was estimated, about 2 per cent. of the mass. A shaft was sunk, but the prospect of the ore occurring, in sufficient quantity to be extracted with profit, was considered to be small.

Several earlier notices of this ore exist, one by Dr. Buchanan, who visited it in the year 1810,[1] when its possession was an object of dispute between two zemindars, Rupnarain and Kadar Ali.

In another account by him[2] he states that it was not galena but antimony, and that he believed the deposit to be inconsiderable.

A subsequent notice is by Mr. Jones, in his account of the Mineral Productions of Bengal.[3] Although he speaks of it as being situated in Kharakpur zilla, his mention of Dr. Buchanan and the two zemindars makes it certain that this was the locality. He speaks highly of the samples which proved to be galena, containing 60 per cent. of lead and an unascertained quantity of silver.

Dr. McClelland has recorded that he received from Mr. Duncan, Deputy Magistrate of the district, a specimen of a similar but richer ore from another locality. The name is not given, but it is said that Mr. Dodd, who reported on the subject to the Government, found the ore to be rich in silver.

Bhagalpur District: Gouripur or Phaga, Lat. 24° 47′; Long. 86° 59′.—At a point between the villages of Gouripur and Phaga there is a galena mine, variously spoken of as the Laksmipur, Phaga, or Fogga mine.

In the year 1878 the sinking of a shaft to test the extension of the lode was commenced, and subsequently a prospectus, with a view to the formation of a company, containing the reports of Mining Engineers and the results of assays, was issued by the holder of the mining rights from the landlord, the Raja of Laksmipur. At the time of writing no company appears to have been formed and work has been suspended.

The vein runs with the metamorphic rocks which strike from north-east to south-west and the dip is 45. One of the reports states that the ore is associated with sandstone, which is certainly a mistake. Information regarding the lateral and vertical extent of the lode is incomplete, but it is stated, in a report by Mr. C. Henwood, Mining

[1] *Vide* Friend of India, Feby. 28th, 1830.

[2] Eastern India, M. Martin, Vol. II, 1837, p. 188.

[3] Gleanings in Science, Vol. I, 1829, p. 282.

Engineer to the Puttiala and Subathu silver, lead, and copper mines, that in the vertical shaft it continued for 28 feet 6 inches, when it dipped out southwards. It was proposed to intersect it again by a cross cut from the bottom of the lode. A sample of galena from the surface yielded to Mr. Henwood 77 per cent. of metallic lead, and a sample assayed by the Chemical Examiner to the Government produced 391 *ratis* of lead out of 500 *ratis* of ore=78 per cent. and 55 chittacks (=103 oz. 2½ dwts.) of silver to the ton of lead.

Another sample assayed in the Geological Survey laboratory yielded 60 per cent. of lead and 58 oz. of silver to the ton.

Some other assays give still higher percentages of silver, but it seems possible that they were not made with suitable apparatus and are not therefore to be implicitly relied upon.

A separate deposit is said to exist three-fourths of a mile north of Gouripur at a locality called Karabank, but regarding it no particulars are available.

The Gouripur mine is 30 miles south of the Bhagalpur Railway station, and about 25 miles from the Baijanath and Simaltollah stations respectively.

Dudijor, Lat. 24° 41′ 15″; Long. 86° 47′.—A mine was also opened here in February 1879. Its position is stated to be 13 miles north-east of Simaltollah and 12 miles south-west of Gouripur. Galena was discovered in the gossan, near the surface, and, according to Mr. Henwood, yielded 71 per cent. of lead and 42 oz. 3 dwts. of silver to the ton of ore (? lead). Other localities in this neighbourhood where ore occurs, but regarding which no particulars are available, are called respectively—

Karda, Lat. 24° 40′ 15″; Long. 86° 47′.

Gonora, Lat. 24° 39′; Long. 86° 46′.

Kejurea; Lat. 24° 40′ 15″; Long. 86° 44′ 30″.—This locality is situated about 4 miles to the west of Dudijor. Here the ore is described as occurring in a saccharine quartzite. Samples of ore mixed with gangue gave 12 per cent. of lead and 46 oz. 4 dwts. 3 grs. of silver to the ton of lead. No actual measurements, as to the extent of this deposit, are available.

Khureekhar; Lat. 24° 50′; Long. 86° 52′ 15″ (A. S., 112).—Between the villages of Khureekhar (or Khyreekhad) and Narea a deposit of galena was discovered by some iron smelters about the year 1866; and in the year 1871, the fact was brought before the notice of the Bengal Government by the Collector, Mr. V. G. Taylor, specimens being forwarded for examination and report to the Superintendent of the Geological Survey. On assay these yielded 52 oz. 8 dwts. 14 grs. of

silver to the ton of lead,—a ferruginous gossan (or *pacos*), yielding 3 oz. 18 dwts. 9 grs. to the ton. No account of the extent of the deposit has been published, but judging from the geological map, it is not improbable that the lode or pocket is connected with some reefs of vein quartz and fault rock which traverse the metamorphic rocks from north-east to south-west in that vicinity. As a further indication of the position of this locality it may be stated that it is situated 7 miles north-north-east of Katuriya, and about 22 miles to the north-east of Simaltollah station on the chord line.

Monghyr District: Chakai Hills.—In the Chakai pargana galena containing a small percentage of silver is said to occur.[1] This is probably the source of the *surma*, which is said to be sold in the local bazaars. As there is no precise indication of the locality, it is perhaps identical with Mahabagh or Mahabank, in the Hazaribagh district, as the mine there is just on the boundary and coincides with the position of the Putro river. This is in lat. 24° 25′; long. 86° 25′.

KHARAKPUR HILLS:—According to Captain Sherwill,[2] a vein of argentiferous galena was discovered somewhere at the base of these hills in 1847, but as the discovery was kept secret the exact locality is not known. The ore on assay in Calcutta was said to have contained much silver. Red lead or minium is reported to have been obtained from the bed of some stream in the Kharakpur hills.

Chutia Nagpur Province.—In the province of Chutia Nagpur lead ores have been found in the following districts: In Manbhum at Dhadka; in Hazaribagh at Mahabank or Mahabagh, Baragunda, Mehandadi, Barhamasia, Nyatand? Nawada, Khesmi, Mukundganj, Parseya and Hisatu; in Lohardaga at Barikhap and Sili; in Sirguja at Bhelounda and Chiraikund. At all these localities the rocks in which the lodes or veins occur belong to the metamorphic series.

Manbhum District: DHADKA, Lat. 22° 48′; Long. 86° 36′—This name has been given to indicate the position of deposit of galena which was discovered in the year 1869. Dhadka has been chosen as it is a well-known place, about 40 miles from Purulia and 65 miles from Midnapur *viâ* Silda, but a more precise description of the locality is that it is situated in a hill of mica schist close to a dih called Jani Jor, where there is an outlying house of the village of Dekia, about 1 mile east of Dhadka.

The galena was found to exist in lenticular masses in quartz and sometimes in a regular gangue stone of brown hæmatite and quartz, in

[1] Statistical Account of Bengal, Vol. XV, p. 31.

[2] Jour. As. Soc. Bengal, Vol. XXI, p. 206.

other words in a true lode. Recently there has been some attempt to test the extent of the lode which was first brought to notice by some Kumars, who found it when searching for iron ore, veins of which occur in the same hill. The first samples of galena which were obtained yielded on assay 119 oz. 4 dwts. 16 grains of silver to the ton of lead, a somewhat exceptional amount. Traces of antimony were also noted. Exploration in this neighbourhood, which has been in progress during the present year, has revealed the presence of one or more distinct deposits from that above mentioned.

The following analyses are by Mr. Pedler :—

	A	B
Lead	79·68	79·49
Silver	0·17	·226
Sulphur	12·33	2·324
Copper and antimony sulphides	1·24	
Iron and zinc	0·96	
Gangue	4·93	2·85
Moisture, loss, &c.	0.69	
	100·	

	oz.		oz.	
The silver in A —	60·92	per ton of galena or	76·34	per ton of lead.
" " " B —	80·99	" " "	101·9	" "

A sample recently assayed by Mr. Mallet contained 99 oz. of silver to the ton of lead.

Hazaribagh District: MAHABANK OR MAHABAGH, Lat. 24° 25′; Long. 86° 25′.—On the Putro river, about 1 mile north-north-west of the village of Mahabank, and about the same distance to the north-north-east of Gulgo, in the Pachamba sub-division of Hazaribagh, Mr. Mallet[2] describes the following section—

(*a*). Hornblende schist overlaid by—

(*b*). Largely crystalline white limestone containing scales of light green mica here and there; this bed is about 6 feet thick and is covered by—

(*c*). A peculiar mixture of garnet and coccolite, containing traces of galena and copper. In places the two minerals are well intermixed; in others the garnet occurs in a pure massive form (so called calderite) only a few feet of this rock (*c*) is seen.

[1] Records, G. S. I., Vol. III, p. 74.

[2] *Idem*, Vol. VII, p. 34.

Specks of copper pyrites and zinc blende were observed in the last named rock, and on the north bank of the river the beds are cut through by a nearly vertical granite vein which contained galena. The limestone appeared to be in useful quantity.

During the past year (1880) this deposit was opened out and some very fine specimens of argentiferous galena with copper pyrites and zinc blende were obtained. A Company was formed in Bombay, bearing the title "Imperial Silver Lead Mining Company, Limited," with a capital of Rs. 6,00,000, having for its declared object the development of these ores.

Owing to the promoters having absconded and other circumstances of too recent and current a nature to be treated here as matter suitable for historical comment, the Company's operations have been in abeyance, and there is no further information available as to the extent of the deposit.

BARAGUNDA, Lat. 24° 4′ 3″; Long. 86° 7′.—In the course of some recent excavations which have been made at the copper mines at this locality galena has been obtained.

MEHANDADI, Lat. 24° 22′ 30″; Long. 86° 20′.—Loose fragments of lead ore (cerussite) were obtained on the surface, a short distance to the east of Mehandadi, according to Mr. Mallet.[1] The nature of the source from whence they were derived is not known, as ground had not been broken. Mehandadi is about 6 miles to south-west of Mahabagh.

BARHAMASIA, Lat. 24° 20′; Long. 86° 18′.—Similar fragments are alluded to by Mr. Mallet (*l.c.*) as having been found at Barhamasia, about 3½ miles south-south-east of Mehandadi. A specimen of cerussite, forwarded by Mr. G. Peppe from this locality, yielded on assay by Mr. Tween 86·52 per cent. of lead, but no silver.

NYATAND, Lat. 24° 30′; Long. 85° 45′.—Under the name Lat, Captain Sherwill, in his geological map of Bengal, indicates a lead mine which was probably in the vicinity of the village of Nyatand. The name Lat is not to be found on modern maps. No particulars appear to have been placed on record in reference to this mine.

KHESMI, Lat. 24° 25′; Long. 84° 45′ 50″.—Similar fragments to those at Barhamasia were found here and at—

NAWWADA, Lat. 24° 25′ 25″; Long. 84° 45′ 12″.

MUKUNDGANJ, Lat. 23° 57′; Long. 85° 25′ 30″.—There are two references to the existence of a lead mine in a hill close to a village with the above name which is situated about 3 miles south of the cantonments of Hazaribagh. The first is by Surgeon P. Breton[2] and the second is

[1] Records, G. S. I., Vol. VII, p. 35.

[2] Medical Topography of Ranigurh, Surgooja, &c. Trans., Med. and Phys. Soc. of Calcutta, Vol. II, p. 261.

in a letter addressed to the Coal Committee by Surgeon Drummond.[1] The exact position of this mine, if it ever existed, appears to have been forgotten.

Parseya, Lat. 24° 10′; Long. 85° 51′.—During the past year some large rolled masses of vein stuff with lead ore, principally galena, were, during the rains, washed out of the alluvium on the bank of the river near Parseya. Mr. Hewitt, Commissioner of Chutia Nagpur, who has kindly supplied information upon this and several other mineral deposits in his division, states that these masses of ore had much the appearance of being only the residuum of an original vein or pocket, the matrix of which had been washed away. No trace of the ore *in situ* could be found.

Hisatu, Lat. 23° 59′ 30″; Long. 85° 3′ 30″.—The lead ore of this locality is first mentioned in a letter from Messrs. Motte and Farquhar, addressed to Warren Hastings and the Council, dated Calcutta, 1777. The ore they state had been analysed, and that it consisted of lead and not of antimony. They applied for permission to work it, and at the same time certain iron mines, as will elsewhere be described in this volume. (Chap. VIII.)

It is again referred to in a letter to Government from Mr. Ramus, the Collector of Ramgarh, who describes[2] it as being situated at Seedipore (Sidpa of the map), in the pargana of Colrampore, about 8 *coss* south of Chattra. Some attempt was made at mining; the ore had previously been supposed by the Raja to be of *surma* or antimony, not of lead. In the Statistical Account of Bengal, it is stated that towards the end of last century the mine was worked for antimony (?) for 13 years, but was abandoned on account of a dispute between the partners. No further notice appears to have been taken of it till the year 1842, when it was re-discovered by Colonel Ouseley.

On the first samples forwarded by him to the Asiatic Society Mr. Piddington reported[3] that 500 grains of average ore contained 1 grain of silver, the equivalent of which he estimates at 70 ounces to the ton of ore. A subsequent assay, however, yielded only a trace of silver. Colonel Ouseley stated that the ore is abundant, in reference to which Mr. Piddington pointed out the necessity of testing the extent of the deposit before any opinion could be formed.[4] Some action appears to have been taken in order to carry out this advice, as a fine set of specimens of galena were received by the Asiatic Society in

[1] M.S., No. 70.

[2] Jour. As. Soc. Bengal, Vol. XII, 554.

[3] *Op. cit.*, Vol. XI, p. 892.

[4] *Op. cit.*, Vol. XII, p. 737.

the year 1845,[1] and in the following year[2] Mr. Piddington published a report on them, in which he states that he failed altogether in finding any trace of silver or arsenic, but that copper was present. The following result was obtained from several analyses of picked and pure ore :—

Water (hygrometric)		2·50
Sulphuret of lead (giving metallic lead 47·2)		54·50
Sulphuret of antimony (giving metallic antimony 12·2)		17·00
Oxide of iron	4·00	25·50
Silicate of iron (?)	21·50	
Bismuth trace		0·00
Loss		50
		100·0

The silicate of iron in this analysis is, to say the least, remarkable. This and some other analyses by the same chemist are, it is to be feared, not quite trustworthy.

At the present day the old excavations and the debris so obscure the outcrop that, without clearing the ground, it would be impossible to form any opinion as to the precise nature of the deposit, whether it is a true lode or merely a pocket. The neighbouring rocks are gneiss with micaceous and hornblendic schists.

Mr. J. Donaldson, in a report on the iron ores of Hazaribagh, mentions that an old revenue map indicates the presence of a lead mine near the village of Murpa. Since this village is situated in the middle of the Raniganj sandstones of the Karanpura field, it is not surprising that he failed to find any traces of ore there.

Lohardagga District: BARIKHAP, Lat. 24° 20′ 30″; Long. 85° 15′ 20″.—Close to a village of the above name, which is about 3 miles north of Balumath, rolled fragments of galena, partly converted into cerussite, have been obtained.[3] The rocks of the vicinity belong to the metamorphic series.

SILI, Lat. 23° 22′ 30″; Long. 85° 54′.—Specimens similar to the above were obtained by Mr. F. Linde close to Sili, on the Subanarekha, samples of which are now in the Geological Museum, but no further particulars have as yet been ascertained.

Sirguja State: BHELOUNDA, Lat. 23° 52′ 30″; Long. 83° 18′ 30″.—Specimens of galena from a hill called Puttia, near the village of Pelowa, in the Ramkola zemindary, were forwarded to the Government in the

[1] Jour. As. Soc. Bengal, Vol. XIV, p. 61.
[2] *Op. cit.*, Vol. XV, p. lxvi.
[3] Mem., G. S. I., Vol. XV, p. 125.

year 1865 by Colonel Dalton,[1] in order that an assay might be made From the original manuscript it appears that this locality, which was only known from native report, was situated about 24 miles north of Pertabpur, so that it corresponds with Bhelounda of the maps, which is, however, not in Ramkola but in Pal, an adjoining tuppeh. The rocks of this neighbourhood are similar granitic gneisses to those at Cheraikund, and they lie on about the same east and west strike.

The specimens of galena forwarded by Colonel Dalton yielded a trace of silver. The clean ore, it was stated, would be worth from £12 to £13 per ton. An attempt to work the mine, by whom it is not stated, proving unprofitable, it was abandoned.

CHIRAIKUND, Lat. 23° 53; Long. 82° 52′.—About 1¼ miles to the south-west of the village of Chiraikund, in the Ramkola zemindary, district of Sirguja, and not far from the south-west boundary of Mirzapur, there is an abandoned lead mine which was formerly worked by a Mr. Burke.

Mr. Mallet[2] describes the ore as apparently occurring in two pockets in a light grey horny quartzite which runs parallel to the surrounding gneiss. Sparsely disseminated galena was found in the quartzite, but there were no indications of the existence of a true lode. Small crystals of cerussite were observed, but there were no traces of antimony.

Central Provinces.—In the Central Provinces lead ores have been found in the following districts: In Sambalpur at Talpuchia, Jhunan and Padampur; in Raipur at Chicholi; in Nagpur at Nimbha; in Jabbalpur at Sleemanabad; and in Hoshangabad at Joga.

With two exceptions these deposits occur in the metamorphic rocks. These are Padampur, where the matrix is a limestone belonging to the Vindhyan (Karnul) series of the Mahanadi basin, and Joga, where the matrix is a band of Bijawar (lower transition) limestone.

Sambalpur District: TALPUCHIA, Lat. 21° 66′; Long. 84° 5′.—South of the village of Talpuchia, on the Ebe river, about 30 miles north of Sambalpur, some rolled pebbles, consisting of a mixture of the oxides and carbonates of lead, were found lying on the surface. Whence they came originally is uncertain, but it is possible that they may have been derived from a small hill north of Talpuchia which consists of fault rock and gossan, and where excavation[3] may possibly prove the existence of a lode. These specimens yielded 87·28 per cent. of metallic lead.

JHUNAN, Lat 21° 32′ 30″; Long. 83° 55′.—The existence of a deposit of galena on the banks of the Mahanadi, near Jhunan, about

[1] Jour. As. Soc. Bengal, Vol. XXXIV, p. 48.
[2] Records, G. S. I., Vol. V, p. 23.
[3] *Op. cit.*, Vol. X, p. 192.

11 miles north-west of Sambalpur, was known by local tradition, but the exact spot was uncertain till the year 1874[1] when by cutting some trenches at right angles to the strike of the granitic rocks, exposed on the banks of the river, a true lode containing galena, with traces of ores of antimony and copper, was laid bare. Lead smelted from this galena yielded on assay 12 oz. 5 dwts. of silver to the ton. The lode, where it was opened up, had a width of from 16 to 19 inches. The strike was from 35° north of west to 35° south of east, with an underlie of 45° to 35° east of north, that of the surrounding rocks being in places 60°. The gangue consists of quartz which is permeated in every direction by nests and strings of galena, but in places massive ore stretches from wall to wall of the lode.

In the year 1875 an excavation was made with a view of tracing the ore inland from the bank of the river, but, owing to the depth of the alluvial covering, the rocks were not cleared sufficiently to render it certain whether the lode continued or had died out. There being no one on the spot capable of carrying on the operations, the work was shortly afterwards suspended.

PADAMPUR, Lat. 21° 45′; Long. 83° 37′ 30″.—In the bed of the Mahanadi, near the village of Padampur, some scattered nests and strings of galena occur in a limestone of the lower Vindhyan series. These indications do not point to the probable existence of a sufficient quantity of ore to be of economic importance.[2]

Raipur District: CHICHOLI, Lat. 21° 5′; Long. 80° 41′.—This name is retained merely to avoid confusion, but it is rather a misnomer, since the locality where the lode occurs is situated about 3 miles to the west of Chicholi, on the Raipur and Nagpur road, and close to the village of Ranitalao.

The discovery of galena was first made in the year 1868, by some stone-breakers who were employed in preparing road metal on a well-defined ridge of quartz, which, striking north and south, crosses the road at the point above indicated. Soon after, it was visited by Mr. R. B. Smart of the Revenue Survey, who prepared a special map of the locality, and wrote a memorandum on the appearance presented by the deposit. During the same year specimens of the ore, which were forwarded by Captain Twyford, Deputy Commissioner of Raipur, proved on examination to contain galena in association with fluor spar in a matrix of quartz. The galena was found to contain a small quantity of silver, but no

[1] Records, G. S. I., Vol. X, p. 191.
[2] *Idem*, p. 192.

antimony was present.[1] Specimens which were subsequently examined yielded 9 oz. 19 dwts. and 6 grains of silver to the ton of lead.

In the year 1870, the locality was visited by Mr. W. T. Blanford,[2] who has described it as follows. The ore occurs in a well-marked vein, composed of quartz, which traverses the metamorphic rocks, consisting of granite or granitoid gneiss and hornblende schist passing into diorite. Besides quartz the vein contains pink felspar in considerable quantities, green and purple fluorspar, epidote, and traces of the carbonates of copper.

The direction of the vein or lode is north 10° east, south 10° west; it forms a series of ridges some 100 feet above the surface; in width it varies a good deal, being in places as much as 30 feet, from which it thins down till it forms a mere wall-like ridge. The galena seen was very thinly disseminated through this, but Mr. Blanford considered that this appearance was not inconsistent with a more abundant supply.

Mr. Blanford mentions the occurrence of two irregularly parallel veins of quartz, 15 miles further east, at Waraband. These were subsequently visited by the writer,[3] who found traces of the copper carbonates in one of them, which is north of the dâk bungalow at Waraband. The other is coincident in direction with a probably faulted junction boundary of the crystalline rocks and the lower Vindhyans of the Chatisgarh basin. It seems not improbable that certain quartz reefs, which traverse the road west of Chicholi, close to the Bagh river, and beyond it, are of the same age as the above, as they present very similar characters; whether they include mineral lodes is a suitable subject for future investigation.

Jabalpur District: SLEEMANABAD, Lat. 23° 38′; Long. 80° 19′.—Some traces of galena were discovered here by Mr. W. G. Olpherts in a bed of quartzite of Bijawar age. The locality was subsequently visited by Mr. Hughes,[4] who could not see any indication of the existence of a true lode, as has already been mentioned in reference to the copper. The galena was somewhat sparingly disseminated in the rock. On assay it was found to contain 19 oz. 12 dwts. of silver to the ton of lead.

Hoshangabad District: JOGA, Lat. 22° 24′; Long. 66° 51′.—Some old mines situated near Joga, on the Narbada, in the district of Hoshangabad, and which are known locally as the *Chandi khadan* or silver mines, have recently been described by Mr. G. J. Nicholls,

[1] Records, G. S. I, Vol. I., p. 37; and Vol. II, p. 101.
[2] *Op. cit.*, Vol. III, p. 44.
[3] *Op. cit.*, Vol. X, p. 185.
[4] *Op. cit.*, Vol. III, p. 70.

Commissioner of Excise.[1] The excavations are in two parallel series on a band of Bijawar limestone. The more northern of these extends continuously for a distance of about half a mile; the depth averages 25 feet and the width 15 feet. The southern series is 250 yards distant; all along it the excavations are narrower and deeper, but are not continuous, and their appearance suggested that parallel and intersecting lodes or leaders had been followed.

The samples forwarded to the Geological Survey Museum did not indicate the presence of a true lode. The galena appeared to be scantily disseminated through the limestone and chert, the percentage of ore to gangue being very small, but they were only taken from the debris lying on the surface.

Silver exists in the galena, according to Mr. Mallet, to the extent of 21 ounces to the ton of lead. But this hardly entitles the mines to be called silver rather than lead mines.

Nagpur District: NIMBHA, Lat. 21° 24′; Long. 79° 9′ 30″.—At Nima or Nimbha of modern maps, about 17 miles north of the town of Nagpur, Captain Jenkins describes[2] the occurrence of loose boulders of galena on some small hills in the neighbourhood. The source from whence these were derived does not appear to have been yet ascertained.

Rewah and Bundelkhand.—The only localities in Rewah and Bundelkhand, where lead ores have been met with, are at Burgowa in the former and near Seonhra and Jhansi in the latter.

BURGOWA, Lat. 24° 22′; Long. 82° 31′.—In the year 1870 some samples of galena, stated to be from near the village of Burgowa, 10 miles south of Burdi pargana, were forwarded to the Superintendent of the Geological Survey for examination.

Two samples yielded respectively 8 oz. 6 dwts. 14 grs. and 5 oz. 4 dwts. 12 grs. of silver to the ton of lead. Burgowa is on crystalline or metamorphic rocks, not impossibly of the Bhelounda and Chiraikund horizon, which has been alluded to above, though nearly half a degree north of the east and west line connecting them.

At the same time specimens were also forwarded from a locality said to be close to the Mirzapur frontier; this may have been Chiraikund. These contained silver in the proportion of 7 oz. 7 dwts. to the ton of lead.

Captain Pearson[3] refers to the discovery of a silver mine somewhere east of Sohagpur, and which was being worked by the Raja of Rewah in 1860. Possibly the story referred to one of these galena localities.

[1] Records, G. S. I., Vol. XII, p. 174.
[2] As. Res., Vol. XVIII, p. 198.
[3] Report on Mundla, 1860, p. 22.

SEONHRA, Lat. 26° 12′; Long. 78° 51′ 30″.—Three miles north-north-east of Seonhra, in the Dattiah territory, the existence of lead ore was brought to notice by Captain J. Ballie. It has since been visited by other local officials, and by the late Mr. W. L. Willson, who considered that the ore is abundant; it occurs in a vein associated with quartz in the Par sandstones. Specimens now in the Museum contain both galena and cerussite.

JHANSI CANTONMENTS, Lat. 25° 26′; Long. 78° 39′ 30″.—Specimens of galena, forwarded by Mr. B. W. Colvin, Commissioner of Jhansi, and which were found on the banks of a small stream in cantonments, yielded on assay 19 oz. 12 dwts. of silver to the ton of lead. The extent and nature of this deposit is not known.

Rajputana.—In Ajmir, Alwar, and Udepur galena occurs and has been mined for. As will be seen the mine at the Taragarh hill in Ajmir was of considerable extent; the others were of less importance.

Ajmir: TARAGARH HILL, Lat. 26° 28′; Long. 74° 41′ 30″ (A. S. 34). —The most important deposit of lead ores in Ajmir territory is situated close to the city of Ajmir, at the foot of the Taragarh hill. The mines, of which there are considerable traces still existing, were farmed by the Mahrattas for Rs. 5,000 yearly, the miners receiving three-fourths of the value of the outturn to cover all their expenses.[1] In the year 1830 the mines were visited and described by Captain Dixon,[2] who states that they had the appearance of having been in operation for many centuries. From Captain Dixon's account it would appear that the ores were of three classes, namely oxides, carbonates, and sulphides. The last mentioned, when in the form of galena crystals, was sold for *surma* for anointing the eyes. True *surma* or antimony is also mentioned as occurring.

It is stated that the final closing of the Ajmir mines was due to the mutiny, and an anxiety on the part of the authorities to make lead for bullets scarce.

According to Mr. Hacket,[3] the ore occurs in a number of small roughly parallel veins running through a quartzite of sub-metamorphic or upper transition age in nearly the same direction as the strike of the rocks. Captain Dixon gives a very interesting account of the method of mining, which is too long for reproduction here. He mentions the occurrence of leaders from the different veins as interlacing and crossing one another so that the deposit seems to be a congeries of true

[1] Ajmir-Merwara Gazetteer, p. 7.
[2] Gleanings in Science, Vol. III, p. 111.
[3] Records, G. S. I., Vol. XIII, p. 247.

lodes. The passages followed the courses of these lodes, and were only large enough to permit of the miners crawling through them. The ore and rubbish was brought to the surface by a most tedious process, baskets containing them being passed from hand to hand by a number of coolies seated within reaching distance of one another.

The preparation for smelting consisted in crushing the ore from its matrix by beating it with wooden clubs, after which it was thrown down the slope of the hill to free it from extraneous matter. It was then collected and washed by hand in conical wooden tubs, and was then kneaded up with equal weights of cowdung into lumps of the size of a pigeon's egg. When dried it was ready for the furnace, a simple structure of clay, 3 feet high, with an upper internal diameter of 11 inches and a lower one of 10 inches; three clay twyeres were luted into the base and served to communicate the blast from three pairs of bellows. Owing to the presence of the cowdung the quantity of charcoal fuel required to smelt the ore was comparatively small, the proportion being from 50 to 75 per cent. to the weight of fused metal. Each furnace turned out from 2 to 3 cwts. of metal daily. The worst ores yielded 31 per cent., the best 50 to 58 per cent., and the average 40 per cent.

Mr. Hacket has pointed out that a considerable discrepancy exists in the accounts as to the amount of the outturn of metallic lead. Captain Dixon placed it at about 850 cwt. per annum in 1830, but though attempts were made to improve the mining by more systematic draining no permanent improvement appears to have been produced. On the other hand, it is stated in the local gazetteer and the settlement report that in the year 1818, the first Superintendent of Ajmir, Mr. Wilder, took the mines under his own direct management, and that they then produced from 10,000 to 12,000 maunds of lead, *i. e.* 6,800 to 8,100 cwts., which was sold at Rs. 11 per maund. It may be, however, that these two estimates refer to different periods, though Captain Dixon does not imply that there had been any falling off.

In 1846, owing to the Ajmir magazine ceasing to take the metal, the mines were closed. Though considered to be purer than English commercial lead, it could not compete with it even at Agra, owing to its cost being Rs. 16 a maund or one-eighth dearer than English lead.

Descendents of the miners still live in Ajmir, but the consumption of lead, which was great in troublous times, has now so fallen that, except the opening of the railway should enable it to be exported to other marts, there is no prospect of its being opened.

None of the accounts mention silver as occurring in this ore. The process of extraction was possibly not known to the miners.

GANESHPURA, Lat. 26° 1′; Long. 74° 42′ 30″ (A. S., 34).—Near a village of the above name, which is situated about 30 miles south of Ajmir, a small quantity of lead ore has been extracted according to Mr. Hacket.[1]

Alwar: JODAWAS, Lat. 27° 21′ 30″; Long. 76° 23′ 30″ (A. S., 50).—At Jodawas, in Thanna Ghazi, in Alwar territory, there are acording to Mr. Hacket (*l. c.*) long open cuttings, 20 to 30 feet deep, from whence it is believed that considerable quantities of lead ores were extracted. According to the Alwar Gazetteer[2] these mines have recently been re-opened, and the ore, which is galena, was found by Colonel Dickens to contain 1 per cent. of silver and 80 per cent. of lead. The name of this locality is misprinted Indawas in Mr. Hacket's account.

GUDHA, Lat. 27° 21′ 30″; Long. 76° 40′ 30″ (A. S., 50).—At Gudha, also in thanna Ghazi, Mr. Hacket says (*l. c.*) that a small pocket of lead ore was discovered, which, on being worked, was found to die out in every direction.

Udepur State: JAWUR, Lat. 24° 21′; Long. 73° 45′.—In the mines at Jawur or Zawar, south of Udepur, which are principally famous for their zinc, galena has also been found. A sample assayed by Mr. Tween yielded silver in the proportion of 10 oz. 12 dwts. 8 grs. to the ton of lead. These mines were closed in the time of the great famine of 1812-13.

Bombay: Panch Mahals District in Gujarat: JUBHAN, AND KHANDELAV LAKE.—These two localities are given under the heading of Panch Mahals as having produced galena; that from the former contained silver in the proportion of 5 oz. to the ton of lead. Specimens of the ore, as it occurred, yielded 58·91 per cent. of metallic lead. No attempt to work the mines has been made since 1874; and, apparently, no authentic information as to the nature or extent of the deposit is available.[3] The Khandelav lake is situated in the Jambughora State, in Narukot.

Balochistan and Afghanistan.—In the former country there are ancient lead mines at Sekran, which are of considerable extent, but are now deserted, it is believed. In Afghanistan at Feringal, and in Chardeh, there are mines evidencing a remarkable degree of mining skill. It is not at all probable that the list which follows includes all the localities where lead ore occurs in these countries, but this is a necessary consequence of our limited knowledge of the geology of Afghanistan.

[1] Records, G. S. I., Vol. XIII, p. 248.
[2] Page 83.
[3] Bombay Gazetteer, Vol. III, p. 197.

Balochistan: Beyla, Lat. 26° 14′; Long. 66° 20′.—Specimens of lead and antimony ores were forwarded to the Bombay Geographical Society by Captain Boyd,[1] who stated that they were found in greatest quantity from Kote Jam-ke-Kot, 40 miles west of Beyla. Ores are said to be washed down in considerable quantities from the Mhor and Pubb mountains.

Sekran, Lat. 27° 48′; Long. 66° 24′.—In Mr. A. W. Hughes' work on Balochistan, an account by Dr. Cook of the lead mines at Sekran will be found.[2]

Sekran is situated about 12 miles west of Kozdar, in the province of Jhalawan. The mines are described as being very extensive, but are now deserted, and Dr. Cooke experienced much difficulty in crawling through the tortuous passages where bones of various animals, which had been brought in by hyænas, were strewn about. The mine is regarded with superstitious dread by the Brahuis of the neighbourhood, who merely break off portions of the rock from other hill sides and manufacture the lead and antimony as required. Mr. Mason, who refers to these mines, says that 200 men were constantly employed in extracting the ore; vast quantities of slag lying about on the surface testify to the former extent of the industry. Some ore was smelted in simple open furnaces by the Mardui tribe of the Brahuis for Dr. Cooke. The rocks, including the ore, evidently from his description are cretaceous limestone, and from his mention of fragments of granite being seen at one of the entrances of the shafts, it is most probable that here, as in parts of Afghanistan, the occurrence of the metalliferous deposit is directly connected with the intrusion of igneous rocks into the beds of cretaceous age. Dr. Cooke says that in one place the rocks resembled an altered claystone, variously mottled and containing small cavities filled with bright red and yellow ochres, and the fracture of some specimens showed a metallic steel-grey appearance (galena?). The statement that the antimony ores are smelted perhaps requires further confirmation.

Major George Le Messurier, who surveyed the route from Kelat to Sunmiani, speaks[3] of the antimony at the Sekran mines occurring in crystals of an inch square imbedded in black vitrified rock. It is added that the lead ore found was of inferior quality and small in quantity. The so-called antimony must have been galena if it occurred in cubes.

Afghanistan: Feringal, or Fringal, in Chardeh, Lat. 34° 45′; Long. 68° 30′.—Under the above name an extensive but deserted lead

[1] Trans., Bomb. Geo. Soc., Vol. II (1839), p. 204.
[2] "The Country of Balochistan:" London, G. Bell and Sons, 1877, p. 81.
[3] Jour., Bomb. Branch, Roy. As. Soc., Vol. II, p. 109.

mine is described by Dr. Lord,[1] who was in the year 1837 in medical charge of the Kabul Mission. It is situated in the upper part of the district of Chardeh, about 30 miles from the entrance of the valley of Ghorband, on the side of hill facing the east, at an elevation of about 250 feet above its base. The hill is composed of conglomerates and quartz rock with a schistose layer interposed.

The mine, which was worked in the time of the Chagatais, is said to be wholly in the conglomerates; this, however, is probably a mistake; its extensive nature may be gathered from the fact that the ore is not reached till after a perpendicular descent of 100 feet, and a total length of galleries of half an English mile have been traversed.

Dr. Lord states that the shafts and galleries show a most surprising degree of mining knowledge, as there is no sign of the ore at the surface on the side of the hill, where the entrance to the mine is situated. Nearly three hours were spent in the exploration of a portion of this wonderful mine, and it is to be regretted that the plan of the works, and a view of one of the chambers by Lieutenant Leech, which Dr. Lord alludes to as affording further details, were not published with the paper. The ore is said to be an extremely rich galena. Other localities where ores of lead occur, mentioned by Dr. Lord, are situated in the valley of Kinchak, and on the road to tha Hindukush, under the village of Kashim.

Lead ores are known to occur in the Hazara districts, in Wardak, and in Shah Muksood and Tirin.

According to Captain Hutton,[2] an impure kind of galena, obtained in the last-mentioned place, is sold at Kandahar to painters and potters at the rate of 3 annas a seer. Pure galena sells at 12 annas a seer, and when purchased and cleaned it was sold as *surma*, so called, at the rate of Rs. 5 to 6 per seer. Manufactured lead from the above mines was sold retail at 11 to 12 annas a seer. A semi-vitrified oxide of lead was employed as a paint in the Afghan Materia Medica, and as a hair dye.

Argentiferous galena from Hazara is exported to the Punjab, and it is also apparently manipulated locally by some process which enables the silver to be extracted.

Punjab.—In the Punjab Himalayas there are a number of localities, especially in the Kulu and Simla districts and the Sirmur State, where lead ores occur, and which have in some cases been worked. The argentiferous galena of Kulu, or the Vazir-i-rupi, has recently attracted some notice, as has been alluded to in Chapter IV.

[1] Jour., As. Soc., Bengal, Vol. VII, p. 533.

[2] Cal. Jour., Nat. Hist., Vol. VI, p. 599.

KHAGUL.—At Khagul, in the Ghari Habibulla jagir, tahsil Mansera, district of Hazara, a small deposit of galena was laid bare by a flood in the year 1877. The locality was subsequently visited by Mr. A. B. Wynne, who reported that the ore occurred in two nests rather than in regular veins, in some grey shining metamorphic slates. The gangue was of quartz and gossan. Mr. Wynne's opinion was that the appearances did not justify any belief in the existence of a valuable deposit. The ore on analysis of the first samples yielded 76 per cent. of lead and a trace of silver. Further samples received afterwards yielded 65 per cent. of lead and 7 oz. 18 dwts. 11 grains of silver to the ton of lead.

Samples of galena from Ugri (Agrar) in Hazara, obtained by Mr. Wynne, are now in the Museum. They occur in a decomposed schist or trap, very sparsely disseminated.

Mari or Murree District: BANDI MUNIM.—Some galena was found in the year 1878 at Bandi Munim, near Gorini, not far from Mari. There is no information available as to its abundance.

KARANGLI, Lat. 32° 46′; Long. 73° 5′.—Both Dr. Fleming[1] and Mr. Wynne,[2] in their reports on the Salt-range, mention the occurrence of galena in small nests and detached crystals in a dolomitic sandy rock of carboniferous age(?). A small mine, to which entrance is obtained by the branches of a tree, which overhangs the escarpment, is worked by the natives, who dispose of it at the rate of Rs. 4 or 5 per *tola* (this must be a misprint for seer or 2 lbs,[3]) to be employed as *surma* for anointing the eyes. In 'Punjab Products' the value of this ore is said to be from 7 *tolas* and 10 *mashas* to 10 *tolas* for a rupee.

The collection of galena on this precipice seems to be like the samphire gatherers, a "dangerous trade," for Mr. S. Bowring[4] says that the "zemindars who search for it let themselves down by a rope over the face of a precipice and pick the mineral out of a hole beneath in the side of the rock, in which perilous adventure some unfortunately have lost their lives by falling down the cliff, a height of 500 or 600 feet.

KHEWRAH GORGE, Lat. 32° 42′; Long. 73° 4′ 30″.—A deposit in every way similar to the above occurs near the temple on the right side of the Keurah gorge, above Pin Dadun Khan, according to Dr. Fleming.

Simla District: SUBATHU, Lat. 30° 58′ 30″; Long. 77° 3′—There are three localities in the neighbourhood of Subathu, where ores of lead

[1] Jour., As. Soc., Bengal, Vol. XVII, p. 517; and Vol. XXII, p. 256.

[2] Mem., G. S. I., Vol. XIV, p. 301.

[3] Which is still a high price, as Kandahar galena sells at Lahore for Rs. 1·8 a seer ('Punjab Products').

[4] Jour. As. Soc. Bengal, Vol. XIX, p. 50.

occur; the first is on the east bank of the stream, near the village of Chapla, or from 2½ to 3 miles south-east of Huriapur; the second is situated between 2 and 2½ miles, on the Solan road, south-east of Subathu, just above the Dhobia Ghât; the third is situated mid-way between these localities.

At the first locality the lode runs parallel to the lamination of the bedding of the rocks in a north-west to south-east direction. These rocks are slates belonging to the Blini series; intercalated with them is a thin band of limestone, which is commonly said to occur near the limit of the metalliferous rocks, but in this case it is 300 yards distant from the lode. The lode itself is stated to be 2 feet thick, but Mr. Willson, from whose notes this account is drawn up, states that though the lode was concealed at the time of his visit, he was inclined to believe, from the character of the samples, that the deposit was a "bunchy" irregular one.

Traces of lead ores with barytes are said to occur to the east of the suspension bridge, as far as the Sairan dâk bungalow, on the Simla road, but that they do not occur to the west.

Under European management mining and smelting was carried on here, but as they have ceased, it is to be concluded that the undertaking was not a profitable one.

At the second locality the lode consists of 2 to 3 feet of nearly pure ore, in a grey siliceous rock, with a more compact grey slaty rock on either side, which contains barytes and zinc blende with traces of copper ores.

To the east of this main lode, at a distance of 80 feet, there is a second lode, 1 foot 6 inches to 2 feet thick, but rather "bunchy" in character. Mr. Henwood, who was in charge of the works, considered that this lode was identical with the first one near Chapla, where, however, the larger one had not been proved, though it was thought that there were traces of its presence.

The mine is situated on the top of a small hill, and the workings include a shaft, 60 feet deep, and a gallery through the 80 feet of rock, which separates the two lodes. Crushing mills, two smelting furnaces, and cradles for washing the ore, were all put up by the Company on this hill.

It would seem that these lodes are situated in fissures caused by the crushing up of the slates. In some parts the siliceous portions of the lodes form distinct ribs marking the position for long distances.

The result of assays of galena from this region for silver will be found in the Chapter on Silver, but the exact mines from which the samples come is not known.

Solan, Lat. 30° 54′ 30″; Long. 77° 16′.—The above name is used for this mine in consequence of its being a well-known locality, but it is actually situated about 6 miles east of it, close to the village of Sar, near the junction of the Ussan and Giri rivers. The latitude and longitude given above is that of the mine.

This mine consists of an adit driven east and west with the lode; when visited by the late Mr. W. L. Willson in 1871 the roof had fallen in, and the mine was full of water, so that no observations could be made as to the extent and character of the deposit. Both lead and copper ores seem to occur, but the references are so vague that this cannot be stated with certainty.

Sirmur State and Jaunsar District: Swinj, Lat. 30° 43′; Long. 77° 47′.—On the banks of the Tons river, about 25 miles above Kalsi, there is a tract of country surrounding Swinj, partly included in Sirmur and partly Jaunsar, where mining for lead has been carried on to a considerable in extent.

According to Captain Herbert,[1] the principal workings in Sirmur were at Aiyur, near Bhatnor or Barthanole, where, owing to the softness of the rocks, the galleries admitted of an erect position, while in the mines called Maiyar and Borela, in Jaunsar, the passages were narrow and tortuous.

The Borela mine, before Captain Herbert's visit, used to pay Rs. 2,000 and the Maiyar one Rs. 4,000; but in his time the rents were Rs. 650 and Rs. 1,000 respectively. The mines were always included in the assessment for revenue. Captain Herbert found great difficulty in ascertaining particulars as to productiveness from the native miners. The ore in all was of the same quality, a steel-grey finely granular galena. The quantity of ore which had been removed must have been enormous, since at Borela alone there were upwards of 80 galleries.

Mr. H. B. Medlicott,[2] who visited this locality in 1862, says that only one mine was then open. The lode, which was about 2 feet wide, was well defined and underlay at an angle of 70° to east-north-east. The galena occurred in a thick steady string, principally next the under wall. Another distinct string was of mixed ore containing zinc blende, with some galena, iron pyrites, and quartz. The rocks in which this lode or series of lodes occur are much disturbed limestones and slates of the Krol and Infra Krol groups.

To the west of this locality, at the gap between Gernani and Gurna, there are also old mines which are said to have been searched for lead.

[1] As. Res., Vol XVIII, p. 256; and Indian Review, Vol. II, 1826, p. 349.
[2] Mem., G. S. I., Vol. III, p. 179.

The assay of some samples of galena forwarded from this region by Mr. Henfrey yielded an average of upwards of 20 ounces of silver to the ton of lead.

The following is the most recent information on the subject of these abandoned mines. It is from a MS. report by Mr. R. D. Oldham in Sirmur.

BARTHENOLE, Lat. 30° 44′; Long. 77° 46′ 30″.—Numerous old workings in limestone.

KUNNA IN JAUNSAR, Lat. 30° 41′ 30″; Long. 78° 4′.— Quartz vein in slates, of which 2 or 3 inches at the base are impregnated with galena and copper pyrites.

KHARSI IN JAUNSAR, Lat. 30° 46′; Long. 78° 2′ 20″.—Galena in nodules between beds of limestone; very local in its distribution.

KONAIN IN JAUNSAR, Lat. 30° 47′ 10″; Long. 77° 56′ 30″.—Galena occurs as at Kharsi.

MUDHAUL IN JAUNSAR, Lat. 30° 56′ 10″; Long. 77° 51′ 30″—Galena said to have been mined for here.

Kulu District· MANIKARN, Lat. 30° N.; Long. 77° 30′ E.—Two to three miles east of Manikarn, in the valley of the Parbutti and close to the village of Uchich, there is a mine known throughout the country as a silver mine. Mr. Mallet found, when he visited the locality in 1863,[1] that the mine was situated in a vertical fissure accessible only by two small entrances on the face of the vertical cliff. Galena was obtained, but it appeared to be sparsely distributed in a quartz, gangue being associated with iron and arsenical pyrites. This galena was not argentiferous, but Mr. Calvert's subsequent explorations seem to show that there are two separate mines, one of galena and the other of arsenical pyrites.[2] It is stated by Mr. Calvert (Ms.) that a sample of ore, apparently a mixture of galena and iron pyrites, on assay by Mr. Johnson, Assayer to the Mint, yielded 22 oz. 2 dwts. 12 grs. of silver and 2 dwts. and 12 grains to the ton of *ore*.

Mr. Calvert states that he discovered lodes of galena also near Karu, Chong, Khanor Khud, Kornan, Kot Kundi, Malanna, Shigri in Lahoul, and other localities. Samples of galena, forwarded from time to time by Mr. Calvert, have been assayed, and the results will be found in Chapter IV.

A sample of galena from Ballarag opposite Uchich, forwarded by Mr. A. G. Young, yielded 65 oz. 6 dwts. 16 grs. to the ton of lead according to Mr. Tween. Mr. Calvert's enthusiasm regarding the Vazir-i-rupi,

[1] Mem., G. S. I., Vol. V, p. 165.

[2] "Kulu, &c.," by J. Calvert: London, Spon., p. 77.

or silver country of the Vazeers, finds general expression in his published work on Kulu, but further information regarding the actual condition and appearance of the mines, and the unopened deposits, is not available at present.

North-West Provinces.—The lead mines of the portion of the Himalayas situated in the North-West Provinces appear to be mostly situated in localities difficult of access. Several of them are worked to a small extent by the inhabitants for local purposes.

Garhwal District.— Lead ores have been found at many localities in these districts, and in some cases there have been mining operations, which have resulted in the removal of every particle of ore. According to Captain Herbert,[1] there is a lead mine in the Nagpur pargana, which would be valuable if situated nearer the plains. Mr. Lawder[2] enumerates the following as being worked, but not extensively: Dhanpur and Tachirda and four deserted mines, namely Gherti, in the snowy range between Milam and Niti, and Rallum Bainskum, on the banks of the Gori river, and Baidli-Baghir. The Dhanpur mine was described by Mr. Barratt,[3] who stated that ore was still abundant, and that the mine was favourably situated for working. He also commended the Jâk mine in *patti Kurra* Kote, in pargana Budhun, but thought that mines at Rai Chendak, 2 miles east of Chund village in Goron and Patal in Dewalgurh, were not of much importance.

Kumaun District.—Deposits of lead exist at Gaul in *patti* Karahi, and close to the Shor Gurang copper mines, the former being galena in limestone. Mr. Barratt also describes a mine in this region, and says that there was no true lode, the ore being disseminated. In Captain Herbert's time the mines were not regularly worked and paid no revenue; when the villagers required lead they simply lit a fire against the rock, and the metal, more or less sulphuretted, trickled from the crevices.[4]

Nepal.—Specimens of argentiferous galena have been received from Nepal, but nothing is known as to the mode of occurrence of lead ores in that country.

Darjiling District: SAKKAN RIVER.—Mr. Mallet[5] found galena in a boulder composed of garnet and hornblende with disseminated pyrites and manganite, but the source of this boulder, which was picked up in the Sakkan river, could not be discovered. There is no record of lead

[1] Indian Review, Vol. II, 1838, p. 349.
[2] Records, G. S. I., Vol. II, p. 88.
[3] Selections from Records, Government of India, Vol. XVII, p. 74.
[4] Economic Geology of Hill Districts by E. T. Atkinson: Allahabad, 1877.
[5] Mem., G. S. I., Vol. XI, p. 83.

having ever been worked in the region including Darjiling and the Western Duars.

Assam.—Within the limits of Assam there appears to be no recorded case of the discovery of any ore of lead. But beyond its frontiers there is undoubtedly ground for believing that a rich deposit must exist.

Bor Kampti.—A specimen of galena received from Mr. Bruce of Sadiya yielded to Mr. Prinsep[1] on analysis one-fourth per cent. of silver to the ton of lead = 89·6 oz. Of metallic lead, the specimen, which was a small one, contained from 60 to 70 per cent.

Another specimen from the same locality, forwarded by Major Jenkins, was reported on by Mr. Piddington,[2] who said it was a rolled fragment not taken from a wrought vein or lode. It did not contain an appreciable percentage of silver, but antimony was present in the proportion of from 3 to 4 per cent. Mr. Robinson[3] speaks of a silver mine in this region, probably meaning Bor Kampti, which is said to yield Rs. 80,000 a year.

Burma.—The occurrence of lead ores at numerous localities in British Burma has been amply proved, but very little is known as to the nature and extent of the deposits.

In Native Burma and the surrounding States there are localities which apparently produce large quantities of lead.

Tenasserim.—Nine localities, to which separate names are not given, are stated by Mr. Theobald[4] to be indicated on Mr. O'Riley's map as sites where galena occurs in Martaban; they have a general arrangement along a north-north-west line of bearing for a distance of 90 miles. The rocks are limestones of the carboniferous period. The exact characters of the deposits at these localities have not been ascertained, or at least placed on record. Mr. Theobald considers that there may be a double mode of occurrence.

There have been some crude attempts at working, but nothing done yet has been of a sufficiently exhaustive character to prove the value of any of them.

Galena has been found in the hills, about 60 miles from Maulmain in the Salween valley, and 30 miles to the north-east of Tounghu. The Tounghu ore yielded on assay an average of 20 oz. 8 dwts. 7 grains of silver to the ton of lead. The Burmans informed the Deputy Commissioner that it contained 15 oz. It was stated that this ore occurred in

[1] Jour. As. Soc. Bengal, Vol. II, p. 438.
[2] *Op. cit.*, Vol. XX, p. 366.
[3] Descriptive Account of Assam, p. 35.
[4] Records, G. S. I., Vol. VI, p. 93.

considerable abundance. The lead ore found to the north of Maulmain has been visited by Mr. M. Fryar,[1] who has reported its occurrence at three localities on the western bank of the Salween; these are the village of Meezine and the Teetalay and Teetameelay hills. At the first the ore is stated to be in a silicious gangue, very difficult to work, and the spot is 18 to 20 miles from the Salwin by a circuitous path. The lead from this galena contained 14 oz. 14 dwts. of silver. At Teetalay the natives smelt the ore which occurs in limestone, but at the time of Mr. Fryar's visit they had not begun mining, contenting themselves with such loose fragments as they could pick up, but there were some old mines at the spot. Mr. Fryar could not ascertain the dimensions of the lode, but he considered the appearances promising. In the Teetameelay hill the matrix is quartz, and would be difficult to work; the lead contained 8 oz. 3 dwts. and 8 grains of silver. Some Shans had prospected the vein but had abandoned it.

Small deposits of phosphates and arsenates of lead have been met with in different parts of the Tenasserim division.

Maingay's Island (Deo Tuan).—Maingay's Island, which lies to the west of King's Island, in the Mergui archipelago, has an area of 15 square miles. On the west coast, close to the sea, the late Mr. M. Fryar[2] was shown a lode of galena in a coarse argillaceous schistose rock. The galena is associated with quartz and barytes.

Samples of this galena, assayed by Mr. Tween, yielded the following results:—

No. 1—Coarse-grained	Lead, 78·15;	Antimony, 8·66;	Sulphur, 13·19
„ 2—Fine grained	„ 81·45;	„ 5·3	„ 13·25

	Oz.	dwts.	grs.	
Lead from No. 1 gave . . .	13	1	8	of silver to the ton.
No. 2 „ . . .	11	8	16	„ „ „
A third sample „ . . .	11	0	0	„ „ „

Tavoy District.—A deposit of galena is said to have been discovered in 1855 on a small stream running into the Tenasserim river.[3] The spot is difficult of access and particulars regarding it are wanting.

A sample of galena from Tavoy, which was assayed by Mr. Tween, contained silver in the proportion of 16 oz. 7 dwts. 19 grains to the ton of lead.

Upper Burma: Shan States.—According to Major Strover galena[4] abounds in the Shan States and could be obtained in greater abundance

[1] Report on the Minerals of the Amherst District, dated 9th June 1873.
[2] Indian Economist, Vol. V, p. 44.
[3] Administration Report, British Burma, 1861-62, p. 39.
[4] Indian Economist, Vol. V, p. 14.

than it is at present. Lead is also imported from Yunan into Upper Burma. Samples of galena from Bhamo have yielded a far higher average percentage of silver than that obtained from Malabar and Tenasserim; *vide* table in Chapter on Silver.

A decrease in the exports of lead from Burma is said to have taken place to the extent of 75 per cent.[1] This lead was chiefly obtained beyond the frontier, where formerly, if not still, a leaden currency existed.

The following statement of exports of lead from Rangoon was supplied to the Geological Survey Office in 1856 by the Collector of Customs[2]:—

Year.	Quantity. Viss.	Value.
1854-55 . .	558,885·25	Rs. 166,382 15 1¼=£16,638 5 10¾
1855-56 . .	428,658·80	Rs. 115,130 13 6 =£11,513 1 11¼

The return of exports in the Administration Reports of British Burma for the past few years do not specify lead as an export. The other metals exported appear to go merely to the Straits Settlements, but the trade is evidently inconsiderable.

[1] A contribution to Burman Mineralogy by P. Doyle, M. E. C. E.: Calcutta, Stanhope Press, 1879.

[2] *Vide* Col. Yule's "Mission to Court of Ava," p. 346.

CHAPTER VII.

ZINC—TIN—TITANIUM—COBALT—NICKEL—MANGANESE—CHROMIUM.

Zinc.—General Remarks.—Rajputana—Afghanistan—Punjab—British Burma. Tin.—General Remarks.—Bengal—Central Provinces—Bombay—British Burma. Titanium. General Remarks.—Bengal—Rajputana. Cobalt.—General Remarks.—Rajputana—Nepal—British Burma. Nickel.—General Remarks. Manganese.—General Remarks.—Madras—Hyderabad—Bengal—Central Provinces—Berar—Rewah—Rajputana—Bombay—British Burma—Upper Burma. Chromium.—General Remarks.—Madras—Punjab.

Zinc: General Remarks.—Zinc occurs in combination with sulphur forming the sulphide or blende, with oxygen-forming zincite, and it also is found as a silicate, carbonate, sulphate and arsenate.

So far as is at present known, all these minerals are of considerable rarity in peninsular India, but stray crystals of blende do occur in association with the ores of other metals in several localities. It will be sufficient to mention these cases *en passant*, as they are not known to be of any real economic importance; and till more has been ascertained as to quantity, there is nothing further to be stated than the fact that the minerals do exist.

In Southern India blende is stated to have been found in Madura. Mr. Mallet[1] has recently described some specimens containing Smithsonite or carbonate associated with blende, which were found in Karnul, but regarding the mode of occurrence nothing is certainly known, but they have a promising appearance. Possibly they came from the Gazalpully mine. In Bengal, in the Hazaribagh district, blende has been found associated with lead and copper ores in the mines at Mahabank and at Baragunda. The only considerable deposit of zinc ores, which has been extensively mined and worked in the peninsula, is the following.

Rajputana: Jawar, Lat. 24° 21′; Long. 73° 45′.—At Jawar or Zawar, in the Udepur State, there are mines in which zinc ores occur, and which were worked formerly, but the facts available are not very distinct. Thus in Colonel Tod's 'Rajasthan'[2] the mines are alluded to incidentally as having yielded an annual revenue of Rs. 2,22,000, but the metal is said to have been tin. This, according to the Rajputana

[1] Records, G. S. I., Vol. XIV, p. 196.
[2] Vol. I, p. 504, note.

Gazetteer,[1] was probably a mistake, as there is no local tradition of tin ever having been found there. The ore appears to be chiefly the carbonate (smithsonite). The rocks in which it is found are probably quartzites of the Arvali series, but no geological examination of the locality has yet been made.

The only published account of these ancient mines is by Captain J. C. Brooke.[2] He says that the ore occurs in veins, 3 or 4 inches thick, and sometimes in bunches, in quartz rock. The pure ore being very friable was pounded, freed from quartz and placed in crucibles, some 8 or 9 inches high and 3 inches in diameter, with necks 6 inches long and half an inch in diameter. Into these necks the metal sublimed on the application of heat in the following manner. The mouths being fastened up the crucibles were inverted and placed in rows on a charcoal furnace. It took three or four hours to complete the fusion of the ore. It is stated that the crucibles used to crack if any fragments of quartz were allowed to remain with the ore. The mines were closed in the famine of 1812-13, and have not since been re-opened.

Afghanistan: GHORBAND, &c.—According to Dr. Lord,[3] in certain volcanic regions near the Ghorband valley, and elsewhere in Northern Afghanistan, an efflorescence of zinc sulphate, locally called *zak*, was common; whether it was employed for any purpose, medicinal or otherwise, is not stated.

Punjab: SHIGRI.—At Shigri in Lahul zinc blende was found by Mr. Mallet[4] in no great abundance, disseminated through the gangue of the antimony ore which occurs there, as has been described on a previous page.

Sirmur State.—At the Sirmur-Jaunsar mines there occurs, associated with the galena, a distinct string of ore which Mr. Medlicott[5] has described; it consists of zinc blende with some galena, iron pyrites, and quartz.

British Burma.—Dr. Mason[6] states that he saw a sample of zinc blende from Tavoy, and he records that Dr. Helfer had obtained an ore of zinc in one of the Mergui islands.

Tin: General Remarks.—Tin is stated to have been found native in rare instances; as the sulphide or stannite it is not of very common occurrence. The only ore which is known to occur in abundance is the

[1] Vol. I, p. 15.
[2] Jour. As. Soc. Bengal, Vol. XIX, p. 212.
[3] *Op. cit.*, Vol. VII, p. 536.
[4] Mem., G. S. I., Vol. V, p. 166.
[5] *Op. cit.*, Vol. III, p. 179.
[6] Natural Productions of Burma, p. 48.

di-oxide or cassiterite which is more frequently spoken of simply as tinstone, and which, if pure, contains 78·67 per cent. of metallic tin.

Within the limits of peninsular India tinstone has been rarely found, and the only localities in extra-peninsular India, where, so far as is known, this ore occurs in sufficient quantities to be of commercial value, are situated in the Tenasserim division of British Burma.

Bengal.—In Bengal tinstone has only been met with in two localities, both of which are situated in the district of Hazaribagh. The principal of these is at

NURGO OR NURUNGA, Lat. 24° 10′; Long. 86° 7′ 30″.—Under the name Lorunga this locality was referred to by Dr. McClelland in the year 1849 as being one where tinstone was found. The village is south of the Barakar river, and about 3 miles south-west of Leda, which is 8 miles to the west of Karharbari. Dr. McClelland[1] described the ore as occurring disseminated in gneiss, and stated that the weathered-out tinstone gravel was found on the surface, 500 yards distant from the village, through a zone 100 yards wide, and extending to an unknown distance with the strike of the strata. There were 40 iron furnaces there, and Dr. McClelland was led to believe that the manufacture of iron was merely a pretence to cover a more lucrative trade; but of this suspicion no subsequent proof could be obtained, and from the men themselves, who were very uncivil, no information was elicited.

About the year 1867, the attention of the late Mr. Lord of Raniganj was drawn to this locality by the fact of some of the native iron smelters having brought for sale at Raniganj what they conceived to be silver. It was ascertained that they had smelted some of the tinstone supposing it to be iron, and on seeing the white metal run had concluded that it was silver. Having obtained the right to mine from the Raja of Palgunj, on an annual payment of Rs. 2,000, Mr. Lord opened a mine and commenced smelting in the ordinary native iron furnaces. While the mine was in progress it was visited by Mr. Hughes, from whose notes, and his own subsequent observations made after it had been deserted, Mr. Mallet[2] prepared a short account of the deposit, from which the following facts are taken.

The ore occurred in three or four lenticular beds or nests in the gneiss, which were seldom more than a foot or two across, although in one or two instances they were as much as 13 feet; they extended for 20 yards in a direction parallel to the bedding of the gneiss.

[1] Report on the Geological Survey: Season, 1848-49.

[2] Records, G. S. I., Vol. VII, p. 35 pp. 19, 59.

The ore consisted of gneiss with thickly disseminated crystals and grains of tinstone. At a depth of 20 yards the nests appeared to be thinning out; and the rock becoming harder and the water troublesome the mine was abandoned. The smelting was carried on in a rather primitive fashion, and according to Mr. Mallet's informant, a native of the place, only 12 maunds of tin, or between 8 and 9 cwts. of tin, was produced.

So far as these operations went their result was to show that the deposit was not one of considerable extent, but they were perhaps on too limited a scale to afford conclusive evidence on this point.

SIMRATARI, WEST OF PIHRA, Lat. 24° 39′ N.; Long. 85° 49′ E.—At this locality Mr. Mallet found a few crystals of tinstone in a lenticular pocket of granite in mica schist. The discovery was rather of mineralogical than practical interest, still it is considered to indicate the possibility of the ore occurring in the granite of that part of the country. Beryl, apatite, garnet, and leucopyrite, which are not uncommonly found associated with tin, were also found in the same region.

Central Provinces: Bustar State.—A communication received from Mr. Vanstavern by the Geological Survey in 1879 suggests the probability of the occurrence of tinstone in the Bustar State. A Gond from a village called Papagudem, who wore a tin bracelet, was seen by Mr. Vanstavern at Dumagudiem. On being asked about it he said that the metal had been made in his own village from some black sand resembling gunpowder which was found there. The name of the village is supposed to be derived from *papamu*, which means tin. In the neighbourhood of Vijapur there is a village marked on the map, called Patargudiem, lat. 18° 46′; long. 80° 54′, which is possibly the place. The rocks in this neighbourhood are all metamorphic.

Bombay.—In Bombay the discovery of ores of tin has been limited to finding mere mineralogical hand specimens, and there is as yet no ground for supposing that ores occur in abundance.

Dharwar District: DAMBAL HILLS, Lat. 14° 15′ N.; Long. 75° 45′ E.—In the gold-bearing sands which take their rise in the Dambal hills Mr. Foote[1] found a few minute grains consisting of a mixture of metallic copper and oxide of tin.

Gujrat: JAMBUGHORA.—A sample of tinstone from Jambughora, east of Champanir, was recently received from Mr. Rogers, late of the Bombay Civil Service, through Mr. W. T. Blanford. No particulars are known as to its mode of occurrence.

[1] Records, G. S. I., Vol. VII, p. 140.

British Burma.—Except in the Tenasserim division, in no part of British Burma are tin ores known to exist in quantity. There are reports of their occurrence in the Shan States to the south-east of Mandalay,[1] and tinstone is found in the Karenni hills between the valleys of the Sitang and Salwin. Mr. O'Riley[2] claims to have traced the stanniferous granite, across into the valley of the Sitang. The Red Karens work the ore at Kah-may-pew, and, it would seem, bring it to Tounghu for sale. A specimen of ore is said to have been obtained in the Zoukthwah stream in the Tounghoo district.

The deposits for which Tenasserim has long been famous are situated further to the south and commencing in the neighbourhood of Ye or Yay, in the Amherst district; they occur at intervals down to Maleewoon, in the extreme south of Mergui, and thence continue to the south-east in the Malayan peninsula, where there are well known tin mines and washings, but which, not being included in the territory now under the Government of India, are not described here.

Throughout this tract there appears to be hardly a single stream bed where, if the sand is washed, traces of tinstone are not to be found. And not only does the ore occur in the streams, but through large tracts it actually impregnates the soil, and this is the case even in some of the islands of the Mergui Archipelago.

The source of this ore is not far to seek; it all comes from the granite range which separates Tenasserim from Siam, and from some subordinate parallel ranges. The ore, according to Dr. Oldham,[3] exists as an essential ingredient of the mass of the rock occurring disseminated through the granite in small crystals, and being similarly arranged to the quartz and felspar. It is most abundant near the lines of junction between the granite and the highly metamorphosed slates with which the former comes in contact. The degradation of this granite by weathering throughout an enormous period of time has supplied the sand, which is now so abundantly impregnated with stream tin.

Owing to the density of the vegetation on the hills they have never been thoroughly explored for lodes or veins, and therefore it is not known to what extent the ore may occur locally concentrated or segregated from the general mass of the rock. Lodes have indeed been discovered, it is said, at some localities, but there are at present no data for forming an opinion as to their abundance or extent. The natives

[1] Major Strover. Indian Economist, Vol. V, p. 14.

[2] E. O'Riley, Deputy Commissioner, Martaban, to Commissioner of Tenasserim, 6th December 1864, and Theobald, W. Records, G. S. I., Vol. VI, p. .

[3] Selections from Records, Government of India, Vol. X, p. 56.

very naturally confine themselves to the stream tin which is easily obtained, and is generally of great purity.

It is not improbable that, supposing the ore to exist, it would, in the lodes, be so mixed with sulphides and possibly arsenates of other metals that it would be impossible for them to reduce it, or at least to turn out tin of equal quality to that which is now produced in their simple furnaces. In certain localities wolfram occurs in association with the stream tin, and where this is the case the ore is of course of less value, and the tin produced from it commands a lower price in the market.

Amherst and Tavoy Districts.—The occurrence of tin at various localities in these districts has been noticed by several writers. It is believed that large quantities of tin were formerly manufactured in Tavoy since the traveller Ralph Fitch records that in 1586 the whole of India was supplied with tin from the 'island of Tavi.' At present the collection of stream tin, if practised at all, is only done so on a very small scale.

KALLEE UNG, Lat. 14° 48′; Long, 98° 10′.—Dr. Helfer[1] obtained tinstone near the above-named river to the south of Ye or Yay, but he seemed to consider that the deposit was dying out there, but rapidly increased further south.

HENZAI, Lat. 14° 36′ N.; Long. 98°. E.—Mr. O'Riley[2] in 1851 obtained stream ore by washing in the various streams which empty themselves into the Henzai basin from the south, through the Oung-Beng-Quin. These streams were said to be washed occasionally for both tinstone and gold by the inhabitants, and that, of the former, 6 to 8 pounds could be obtained by a woman washing for part of a day. He estimated that a man might, if properly directed, obtain 18 to 20 lbs. daily.

MYIT-TA, Lat. 14° 12′ N; Long. 98° 30′ E.—Apparently the same locality as the above of the latest map is Dr. Helfer's Metamio, 40 miles distant from Tavoy. He states that it is in a tract of country of which the latitude of Tavoy passes through the centre, and which is about 60 miles long, and from 8 to 12 miles broad. The streams containing the tin run into the basin of the Upper Tenasserim river. The ore is stated to occur both in the alluvium and in the granitic detritus on the hills, being in places apparently rather abundant, much more so than it is to the west of the range which separates the valley from the neighbourhood of Tavoy town. Some of the old pits worked in the Burmese time were 40 feet deep.

Captain Low,[3] in his history of Tenasserim, mentions mines and smelting works at Bubeinchaung, near Ke-up-poeh, which were being

[1] Second Report on Provinces of Ye, Tavoy and Mergui, Calcutta, 1839, p. 29.

[2] Selections from Records, Bengal Government, Vol. VI, p. 3.

[3] Jour. Roy. As. Soc., Vol. III, p. 47.

worked in 1825 when he visited them, and deserted mines at Nayedaung, and also at Shenze, near Kaleaung and Kamanula, one day's journey to the north of Ke-up-poch. These mines used to be worked during four months of the year, and gave employment to 400 men. The revenue from them probably did not exceed 1,500 tickals. Captain Low describes the operations as follows. With a shallow wooden basin the workmen simply washed the gravels in the beds of streams, and when they had obtained sufficient ore they returned to Tavoy, where it was smelted the tax amounted to 10 per cent. or more, as the Government took the metal at its own valuation. The trade was a poor one and less profitable than others, but its speculative character proved an attraction to the Burmese. The scarcity or badness of the water had caused many of the best mines to be deserted.

Mergui District.—There are numerous localities in the Mergui district where stream tin occurs, and in a few instances the ore has been found *in situ*. Were it not for the density of the vegetation in the thinly inhabited jungles whence it comes, there ought to be no very great difficulty in finding the sources. Mr. Fryar,[1] who visited the principal works, states that they may be enumerated under 11 heads as follows:—

Palouk, Lat. 13° 15′ N.; Long. 98° 40′ E.—This place is alluded to in a communication which was made to the Asiatic Society in the year 1829, by Mr. D. Ross;[2] it was stated on the authority of Major Burney that some Chinese who had visited it had stated that the ore was superior to that at Junk Ceylon, an island off the coast of the Malayan Peninsula. Dr. Helfer apparently refers to this locality under the name Palow, but it may be that it is a place a little further south. He also mentions Womboo to the north of Mergui.

In three tributaries of the Palouk river, named Koosheclo, Walach, and Natheechoung, 18 miles from the village of Palouk, Mr. Fryar obtained evidence of the existence of an abundant supply of stream tin in what he considered to be profitable quantity. There are no workings there at present, owing, it is said, to the dearth of inhabitants.

Mergui, Lat 12° 26′ N; Long. 98° 35′ E.—A bed of quartzose sand, which includes large pebbles on the island upon which Mergui is built, contains stream tin in small quantity; it used formerly to be worked, according to Dr. Helfer; and Mr. Fryar states that it used even to be worked in gardens in the town itself.

[1] Letter and Reports to the Chief Commissioner of British Burma, 17th December 1871, &c.

[2] Gleanings in Science, Vol. I, p. 143.

KING'S ISLAND between Lats. 12° 19′ and 12° 42′ N.; Long. 98′ 9°.—Dr. Helfer mentions that he had heard reports of the existence of tinstone on King's and Domel Islands, and Mr. Fryar, who visited the former, found stream tin in the bed of the Kitan river near the sea, and 8 or 10 miles from the hills, so that he concludes that a large quantity is obtainable since there have never been workings there.

KAHAN HILL.—Captain (now General) Tremenhere has in several papers described the tin deposit at this locality, and his operations in reference to its exploitation. The spot where the tin was found is situated near the Tenasserim river, about 11 miles from Mergui town.

Captain Tremenhere [1] described the tin as occurring in a vein of decomposed granite which penetrated sandstone; this geological anomaly in itself suggests that there was some mistake, and an investigation carried out by Mr. Fryar in the year 1872 showed that the deposit, which had been originally found at the bottom of a well, consisted of stream tin in a bed of friable micaceous felspar, and as a similar bed is interstratified with the sandstone at the top of the hill, it is concluded that the lower one consists of the same materials brought down by the wash of the rain and re-formed. In the year 1842, about 12¼ cwts. of ore were raised here by Captain Tremenhere. Mr. Fryar's opinion is that the tin is too thinly disseminated in the bed to make it probable that it would pay to work it; and that it would be more profitable to work the recent pluvial accumulations of debris at the foot of the hill.

THEANDAW, Lat. 12° 20′; Long. 99° 15′.—This, which is a river tributary to the Great Tenasserim, is, as suggested by Mr. Fryar, identical with Thengdon, which in 1841 was considered by Captain Tremenhere [2] to be one of the richest sources of tin in the whole district; but although there were many old pits there, nothing was being done at the time of his visit, and the same was the case when Mr. Fryar went there in 1871.

THAWBAWLEEK RIVER, Lat. 12° 4′ N.; Long. 99° 20′ E.—In this river, which is a tributary of the Ta-Ket, which is again a tributary of the Little Tenasserim, there are and have been for many years somewhat extensive washings for stream tin. Channels are made in the bed of the river, and the water turned into them, and with an ingeniously made cane shovel the large boulders and pebbles are lifted out, and the tin sand, which is sifted by the stream, is ultimately recovered by hand-washing in small conical wooden dishes.

[1] Jour. As. Soc. Bengal, Vol. XI, p. 841, with a plan.

[2] Jour. As. Soc. Bengal, Vol. X, p. 846, where Thengdon is said to be a misprint for Thengdaw.

Mr. Fryar mentions two other localities, Belamo and Seboopela, in this neighbourhood or general tract where ore was or had formerly been obtained. The tin-workers at the last-mentioned earned as much as Re. 1 a day. Another locality in this region, mentioned by Captain Tremenhere,[1] is Zahmon in the Nunklai district, about 20 miles south-south-east of Mergui. The ore is of dark colour and inferior quality, owing to the presence of wolfram. An analysis of this ore gave—

Iron	4·69
Tungstic acid	29·46
Sulphur	1·37
Earthy residue and tin	64·48
Total	100·

The tin manufactured from the ore of this locality sold for 10 per cent. less than that produced at Kahan.

YAGNAN, Lat. 11° 30′ W.; Long. 98° 48′ E.—This locality is 70 miles south of Mergui. The river bearing the above name is only navigable at high tide and by the smallest boats. The tin washings are 2 or 3 miles up the river, and are only worked during the rains. There are about twelve washers, and the ore is taken to Bopyng, where it is sold for Rs. 3-8 per *pee*, equal to about £36 per ton. The earnings of each man during the season average Rs. 100.

BOPYNG, Lat. 11° 15′ N.; Long. 98° 48′ E.—Is 30 miles round the coast south from Gagnay; the village is 10 miles up the river, and the principal washings 5 miles further up. There were here four Chinese and three Shan employers of labour. The coolies received from Rs. 10 to Rs. 15 a month, and a good workman could obtain 2 viss, or 7·3 lbs. of ore by washing in a day. There was a small furnace here belonging to one of the Chinese, to which the others brought their ore and paid at the rate of Rs. 40 a ton for permission to smelt. A sample of tinstone, which Mr. Fryar saw here, and which had been brought from a hill-side several miles further inland, led him to conclude that an actual lode might exist in the hills.

KALA THOOREE, Lat. 10° 52′ 30° N.; Long. 98° 45′ E.—Is 30 miles by the coast from Bopyng. There are thirteen separate washings, but not more than fifteen men are employed. There were only five houses occupied when the village was visited by Mr. Fryar, and the falling-off in the population was thought to be probably due to a diminished supply of ore.

[1] Jour. As. Soc. Bengal, Vol. XI, p. 847.

The earnings were much the same as at Bopyng. The tin-bearing stratum is about 3 feet thick, and underlies 4 feet of dark-coloured soil.

CHOUNG TANOUNG, Lat. 10° 50′; Long. 95° 40′.—Is 4 miles south from the Kala Thooree estuary, and the washings are from 8 to 10 miles up the river. The cutting into the river bed was 242 feet wide. All the labourers, averaging a dozen, were Chinese, and the outturn in one year was between four and five tons weight of tin pigs which were sent to the Mergui market.

Mr. Fryar's description of the smelting furnace, which applies also to those at other localities, was as follows: The furnace is built of clay and strengthened and supported by upright iron bars, which are bound to the clay by iron hoops. The blast is produced by a long wooden cylinder and piston moved backwards and forwards by manual labour. The tapping hole is kept open, and the molten tin is accumulated in a well, till there is sufficient to ladle out and cast into a pig. For each ton of metal from 1·9 to 2 tons of tinstone are required. At different localities, however, the percentage obtained varies from 52 to 68 per cent. One furnace worked by six men produces 400 lbs. of tin in the 24 hours. The slags are passed through six times before being thrown away.

Mr. Fryar estimated that at Lanya the profit per ton of metal was £38 14 0, which was arrived at as follows:—

Cost of tinstone for 1 ton of metal	£48	10	0
Furnace expenses	10	0	0
Carriage to Mergui	1	10	0
	£60	0	0

Price received from merchants at Mergui, £98 14.

PAKCHAN, Lat. 10° 28′; Long. 98° 10′.—This village is situated about 40 miles up the Pakchan river. Tin sand is obtained at a place three days' journey from Pakchan. Sixty men are employed, and all is sent to Ma-lee-won furnace for smelting. Between this and Ma-lee-won there are several other localities where tinstone is washed for.

At Rhenoung, in Siamese territory, on the opposite side of the Pakchan, there are also tin works. The sand is brought on elephants from the stream a day's journey off, and 2,000 men are engaged in tin-getting, according to Mr. Fryar. This locality was also visited by Dr. Oldham,[1] who was much struck with the system adopted by the proprietor of

[1] Selections from Records, Government of India, Vol. X, p. 57.

Governor, an old Chinaman. Everything was most orderly; the feeding of the men being no less so than the preparation of charcoal for the furnaces and the shipping of the metal to Penang.

MA-LEE-WON, Lat. 10° 12′; Long. 98° 40′.—This village is situated on a tributary of the Pakchan river, and it is the most southern of the localities in Tenasserim where tin is worked for; the principal washing is 8 miles from the village, and when visited by Mr. Fryar there were about 70 Chinese coolies employed. The river-bed is 300 feet wide, and the tin-bearing stratum is from 15 to 27 feet beneath the surface, and is only itself 2 feet thick, but it is very valuable for the amount of tin sand which it yields. The lessee Tsit Tschan employed altogether 200 men at different localities, and apparently derived a large income from the industry and from tolls levied on sub-lessees. Between the years 1860 and 1870 the annual rent for Ma-lee-won mines charged by Government was £272.

About the year 1873[1] the township of Ma-lee-won was leased to Messrs. Steel and Company, a firm of Rangoon merchants, with the view of manufacturing tin on a large scale; it is stated that besides the abundant supply of stream tin, veins of ore had been discovered and opened in the hills. The lease was for 30 years at a ground rent of £1,000 per annum, which merged into a royalty of 7 per cent.

During the year 1874-75, 14 tons of cleaned ore and 7 tons of metal were exported. Machinery was erected and roads were opened out, but in 1877 the lease was abandoned, as the expenditure had exceeded the outturn by a large amount. It is considered doubtful whether after this disappointing experience European capital will ever again be risked at Ma-lee-won.[2] At the annual rent of £272, the Chinese, with less capital and smaller current expenditure, were enabled to make the work pay and they are now reinstalled there with from 80 to 100 workers.

In the year 1877-78 there were apparently in the whole of Tenasserim only 12 washings worked by Chinese; for these, ground rents, varying from £10 to £210, were paid. The tin exported was—to Penang 205 cwts. valued at £725, and to Rangoon 482 cwts. valued at £1,737; total 34 tons 7 cwt. valued at £2,462. Besides the ground rent the Chinese pay a royalty of 5 per cent. on the market value of the tin exported.

The following table by Mr. Fryar may be of use as showing the cost of collecting the stream tin, but with the fluctuation in the price of tin, and with the uncertainty which still exists as to the possibility of ob-

[1] Administration Report, British Burma, 1874-75.

[2] *Idem*, 1877-78, p. 35.

taining a sufficient supply for a large factory, it would be useless to attempt to set forth the possible profits which might result from European enterprise :—

Stream tin works.	Produce per man.	Rate for each *pee* of 21·90 lbs. of ore.
	lbs. lbs.	Rs. A. P.
Thabawleek	$4\frac{1}{2}$ to $5\frac{1}{2}$	2 0 0
Gagnan	5	3 8 0
Bopyng	5 to $7\frac{1}{4}$	2 3 0
Kalathooree	$2\frac{1}{2}$ to $7\frac{1}{4}$	3 3 6
Choung-ta noung . . .	5 to $7\frac{1}{4}$	2 4 0
Ma-lee-won . . . , .	$3\frac{1}{2}$ to 6	3 1 4

The price of ore apparently varies from £29 to £41-5-7 per ton.

Titanium : General Remarks.—Titanium does not occur native. Its most common mode of occurrence is in combination with oxygen and iron as titaniferous iron, menachanite or ilmenite. Combined with oxygen alone it forms titanic acid, which is otherwise known as rutile. It is unnecessary here to mention the other combinations in which titanium occurs, with calcium, silica, &c.

The precise effect of titanium when present in iron is somewhat obscure. As much as 1 per cent. occasionally occurs in pig-iron and gives strength to the metal; and wrought-iron or steel is of better quality when made from pig of this character, but as the titanium is then no longer present in the metal its influence must be produced by some indirect action.

It is believed that the good quality of some varieties of iron produced in India, by the direct process, is attributable to the presence of titanium in the ores from which they are made. Ores containing 8 per cent. and upwards of titanic acid are refractory and difficult to smelt, and it is on this account that the unqualified statement is sometimes made that the presence of titanium in iron ores is injurious.

The distribution of titaniferous iron ores in India is not very well known. But it is probable that with the black magnetic iron sands which are found in the beds of streams traversing the metamorphic rocks at intervals all over the peninsula, more or less titaniferous iron would generally be found to be associated.

Bengal.—In the south-eastern portion of the district of Manbhum in Bengal, more especially in the neighbourhood of the village and thanna

of Supur, large masses of ilmenite are sometimes to be seen weathered out from the quartz veins and lying strewn over the surface; occasionally too lamellar plates or seams have been seen there *in situ* in quartz veins.

Rajputana: Alwar State.—According to Mr. Hacket,[1] rutile or titanic acid occurs in some quartz veins which traverse the Arvali rocks of the Motidongri range, a short distance south of Alwar.

Cobalt: General Remarks.—Cobalt is not found native. Its principal modes of occurrence are in various more or less complex combinations with sulphur, arsenic, and alloyed with nickel. It also combines with carbon and phosphorous.

But two or three localities are known in peninsular India where ores of cobalt are found. These are at Babai, Bagor, Singhana, and perhaps some of the neighbouring mines in the Jaipur State in Rajputana. Samples of cobalt ores have, however, been received from two of the extra-peninsular regions, namely Nepal and Burma.

Rajputana: Jaipur State: Babai, Lat. 27° 53′; Long. 75° 49′.—An ore of cobalt called *saita* or *sehta* has long been known to the natives as occurring in the copper mines near Babai and Bagor in Jaipur, 8 and 2 miles respectively south of the mines at Khetri. The first published notice of it appeared in the year 1831 by a writer who simply signed himself A. E.[2] (? Captain Boileau). He described it as a fine grey sand resembling iron filings. It was sold at the mines for from Rs. 40 to Rs. 100 per maund, and was used for colouring glass bangles.

In the year 1845 a mineral from Jaipur (misnamed in the original Syepoore) was described by Mr. J. Middleton[3] as a sulphide of cobalt, and for it the name Syepoorite was proposed by Nicol in his Manual of Mineralogy. Mr. Mallet [4] has recently suggested, but with all due caution, a doubt as to the accuracy of the original analysis. If it should prove to have been inaccurate, it will perhaps be a consolation to those mineralogists, to whom the possession of a sample of this cobalt sulphide has long been an object of desire, to know that neither it nor Syepoore ever had any existence. This is one of those cases, however, where the proof of a negative is so difficult.

The mineral known as *saita*[5] has been partially analysed with the aid of the blowpipe by Major Ross, and more recently a full analysis by

[1] Records, G. S. I., Vol. XIII, p. 249.
[2] Gleanings in Science, Vol. III, p. 380.
[3] Procds., Chem. Soc., Vol. III, p. 39.
[4] Records, G. S. I., Vol. XIV, p. 190.
[5] In the Panjab, where it is imported from Jaipur, it bears the name *Zaffre*.

*Mr. Mallet has clearly demonstrated that it, or rather one part of it, has a complex composition as follows:—

Sulphur	19·46
Arsenic	43·87
Antimony	tr·
Cobalt	28·30
Nickel	tr.
Iron	7·83
Gangue	·80
	100·26

This mineral occurs in crystals which are modifications of the cube, and Mr. Mallet has determined it to be cobaltite. A distinct mineral which occurs with it, but which is separable by its crystalline form (orthorhombic), he has determined to be danaite or arseno-pyrite with cobalt. Jaipurite, as originally described, has therefore not been met with by him, but he suggests that possibly Mr. Middleton's ore may have been from a different mine.

The uses of this *saita* have been already referred to. In the "Rajputana Gazetteer" it is said to have been formerly extensively used for colouring enamels and bangles blue, and that it was capable of producing a rose colour on gold, an art unknown in Europe. In the Jury Reports of the International Exhibition of 1862, there is some account of the process of enamelling on metal, as practised at Jaipur, but the production of the colours was a secret only known to certain families, except as regards the different shades of blue, which are stated by the jury to be produced by an oxide of cobalt. This oxide is doubtless prepared by roasting the above described cobaltite.

According to Colonel Brooke,[1] the present price of *saita* is Rs. 50 for a Jaipur maund of 53 lbs., the royalty on which is one-fifth. Not more than 200 lbs. is produced at any particular mine in the year.

Nepal.—A specimen of cobaltiferous 'matt' from Nepal was found by Mr. Mallet to contain 11 per cent. of cobalt. Nothing was ascertained as to the origin of the materials constituting this undoubtedly artifical product. It seems to be not improbable that they may have been obtained in the local copper mines.

British Burma: Tenasserim Division.—Mr. Theobald states that he obtained a sample of earthy cobalt, with which manganese was associated, from the neighbourhood of Henzai.[1] It was a nodular mass of a

[1] Jour. As. Soc. Bengal, Vol. XXXIII, p. 524.

black colour, enveloped in white clay, not more than an ounce weight altogether.

Nickel: General Remarks.—There are many ores in which nickel is a constituent. It occurs in combination with sulphur, arsenic, antimony, carbon, and silica; it is an essential component of certain ores of cobalt, and is often found in pyrrhotite or magnetic pyrites. The metal nickel is principally used in the manufacture of German silver, and of late years the demand for it for this purpose has increased; the annual outturn (in 1874) being limited to about 600 tons, the price within a few years rose from 4 to 11 shillings per pound. At present it costs only 3 shillings per pound. One of the present sources of supply is a silicate called garnierite, which is worked to some extent in New Caledonia.

In India traces of nickel have been found in several ores, especially in those in which cobalt also occurs in the mines in Rajputana.[2] Recently Mr. Mallet found that both cobalt and nickel were present in pyrrhotite from the Khetri mines, and in the iron ores from Bhangarh there were traces of nickel.

Traces of nickel, in association with copper, have also been found by Mr. Mallet[3] to occur in the veinstone in which the Kandahar gold occurs.

Manganese: General Remarks.—The ores of manganese are numerous, and they are somewhat widely disseminated, though their occurrence in quantity locally is rather unusual. The commonest ores are manganite or the grey oxide; wad or the earthy protoxide; pyrolusite or the black peroxide; psilomelane a combination of the oxide with baryta; hausmanite or peroxide occurring with other ores of the metal; and braunite or binoxide in combination with iron peroxide, silica, and magnesia.

The principal sources of manganese ores are perhaps, in the majority of cases, situated in the older crystalline or metamorphic rocks, still they sometimes occur in younger sedimentary and unaltered rocks. In India indeed, as will be seen below, a not unfrequent source is laterite, though in such a rock the deposits can scarcely be expected to be very constant over large areas. It is possible that manganese is much more abundant in this association than is generally thought, as on the weathered surface it resembles ordinary laterite and might easily escape detection.

The uses to which the ores of manganese are put in the Arts are somewhat varied. They are extensively employed in glass-making and staining; in the preparation of enamels; painting and glazing pottery; and in the

[1] Records, G. S. I., Vol. VI, p. 95.
[2] *Idem*, Vol. XIII, p. 248.
[3] Mem., G. S. I., Vol. XVIII, p. 56.

production of oxygen, chlorine and calcium chloride. Of late years their employment in the manufacture of iron, and steel by the Bessemer process, the latter especially, has worked a marvellous change in the iron trade. The *spiegel eisen* of Germany, which is the form in which the manganese is generally applied to the purpose, is either prepared by an artificial mixture or by the use of franklinite, an ore of iron which contains manganese. The effect of the addition of 10 per cent. of *spiegel eisen* to the charge in the Bessemer converter is to replace the carbon which has been consumed. The silica in the iron becoming oxidised too combines with the oxide of manganese and forms a fluid slag.

The ores of manganese were also employed in the production of steel by the methods invented by Mushet and Heath respectively. Various highly carbonised compounds of iron and manganese have been recently proposed, and in some cases adopted, as substitutes for *spiegel eisen*.

Madras.—According to Dr. Balfour, ores of manganese occur in the following districts and States; but the amount of authentic information as to the nature and extent of the deposits, respectively, is very limited: Nilgiris, Mysore, Kadapah, Karnul, Bellary, Vizagapatam, Hyderabad.

Nilgiris.—Major H. Congreve states that he obtained an ore of manganese in combination with iron at Kunur, and Captain Newbold[1] mentions that it had been found by General Cullen and Dr. Benza in some iron ore near the lake at Ootacamund and in the Kaiti valley, but evidence that it is abundant at either of these localities does not appear to have been published. The same remark also applies to the occurrence of a probably similar ore in Mysore, to which early reference was made by Sir W. Ainslie in his 'Materia Medica of Hindustan.'

Vizagapatam District.—Specimens of manganese ores from Vizianagram and Bimlipatam were received from Dr. A. Hunter of Madras by Dr. A. J. Scott, who made an analysis of them in Edinburgh, obtaining the following results:—[2]

	Vizagapatam.	Bimlipatam
Silica	8·3	9·09
Peroxide of iron . .	12·91	11·72
Magnesia	2·339	0·668
Lime	...	1·244
Red oxide of manganese	73·786	76·177
Oxygen	1·864	0·655
Water	0·539	0·432
	99·735 = Mn. 53·428°/₀	99·986 = Mn. 54·929°/₀

[1] Madras Jour. of Lit. and Sci., Vol. XXII, p. 253.

[2] Edinburgh New Philosophical Journal, Vol. LIII, p. 277.

The Vizagapatam ore, which, according to the above analysis, is considered by Dr. Scott to approximate most nearly in character to a variety called marcellin by Damour from St. Marcellin in Piedmont, is said to occur in large irregular masses of several tons weight. Its specific gravity is 4·50. Dr. Scott supposes the including rock to be laterite.

Manganese is said to be obtainable at Bimlipatam for 2 annas a maund.[1]

Hyderabad: BEDAR, Lat. 17° 54′; Long. 77° 35′.—Captain Newbold recorded that he found manganese-and-iron ore in veins in the laterite which forms the cliffs, 16 miles west by north from Bedar, in the Nizam's territories and close to the line of junction between that rock and the trap upon which it rests. These veins traverse the laterite in all directions, giving rise to a reticulated appearance. It seems from the description that although the veins are thin, a large quantity of ore might be obtained there, but as to its quality nothing is yet known.

Bengal: Singhbhum District.—Manganiferous limonite is found in some abundance in the neighbourhood of Chaibassa, in Singhbhum.[3] Should the projected line of railway to the Central Provinces be made in that direction, it is conceivable that these ores might be brought to mix with those of the Raniganj. The amount of manganese contained in them has not yet been ascertained, but of the ores there is an unlimited supply.

Central Provinces: Jabalpur District: GOSALPUR, Lat. 23° 23′ 30″; Long. 80° 7′.—A deposit of manganese ore, in the neighbourhood of Gosalpur, has long been known to the natives, as it was formerly worked by some local glass-blowers, but it does not appear to have ever been exported. In the year 1875 Mr. W. G. Olpherts, C.E., brought its existence before the notice of the Government, and subsequently an early opportunity was taken by Mr. Medlicott of examining it. He found that it occurred somewhat obscurely in laterite, but did not form either a regular lode or vein, nor was there any apparent connection between it and the underlying transition rocks. The laterite is apparently of the older non-detrital type, and it was considered that the manganese was innate. Mr. Medlicott saw no reason for doubting, in spite of the irregular mode of occurrence, that a large supply of the ore might be obtainable at this locality.

[1] Vizagapatam District Manual, p. 155.
[2] Jour. As. Soc. Bengal, Vol. XIII, p. 992.
[3] Mem., G. S. I., Vol. XVIII, Part II, p. 87.

Mr. Mallet's analysis[1] of a sample gave the following result:—

Manganese calculated as protosesquioxide	75·86	= metallic manganese 54·66
Oxygen	9·96	
Iron sesquioxide with trace of alumina	4·53	
Baryta	3·55	
Phosphoric acid	·28	
Insoluble in hydrochloric acid	2·74	
Combined water	2·41	
Hygroscopic water	·28	
Total	99·61	

The ore consists of dark steel-gray, finely crystalline pyrolusite, with a varying proportion of psilomelane, but the latter is absent in some specimens. The available oxygen is 15·25=83·00 of peroxide, which is therefore about as much above the average as that in the Nagpur ore is below it. With reference to the presence of baryta in this ore, Mr. Mallet mentions that baryta occurs in some abundance at Imlia near Sleemanabad, 20 miles north-east of Gosalpur.

Nagpur District.—The existence of manganese ores in the metamorphic rocks north of Nagpur appears to have been first alluded to by Captain Jenkins[2] and Dr. Voysey.[3] The former merely states that a rich black oxide is abundant, and the latter that a foliated black ore occurs in great quantity associated with metamorphic rocks, which are seen at Nayakhund, Parsuni, and in the bed of the Pesh river. Later and more definite information gives exact localities in this region.

RAMTEK, Lat. 21° 24′; Long. 79° 21′.—Three miles west of Ramtek, and on the south-east side of the Munsur trigonometrical station, a hill about 20 miles north-east of Nagpur, there is an outcrop of manganese ore which was brought to notice by Lieutenant R. E. Oakes in 1859, and has more recently been described by Mr. Wilson, Executive Engineer of the Kanhan Division, as being 10 feet thick and traceable in a north-west to south-east direction for a quarter of a mile. A sample of about 20 lbs. of the ore, which was forwarded by Mr. W. Ness, has been analysed by Mr. Mallet,[4] who found that it consisted of finely granular and indistinctly crystalline braunite with included rhodonite. On analysis the specimen

1 Records, G. S. I., Vol. XII, p. 99.
2 As. Res., Vol. XVIII, Pt. I, p. 198.
3 *Idem*, p. 127,
4 Records, G. S. I., Vol. XII, p. 73.

yielded the following results, the manganese being all estimated as sesquioxide :—

Manganese sesquioxide	78·64	79·39
Iron	9·78	9·87
Lime	1·20	1·21
Magnesia	tr.	tr.
Oxygen in excess of that required for M_2O_3	1·65	1·67
Silica	6·00	6·06
Phosphoric acid	·21	·21
Combined water	2·61	2·63
Hygroscopic water	·60	
Disseminated rhodonite	·35	
	101·04	101·04

In the second column the composition is given exclusive of moisture and the rhodonite, the latter being generally separable. The excess of oxygen and the presence of water show that the braunite is probably in a partially altered condition. The ore contains 55·27 of manganese, and the amount of available oxygen for oxidising purposes would be about 9·71 per cent., which is somewhat less than that in the usual commercial ores, which ranges from 11 to 14 per cent.

KODAIGOWHAN, Lat. 21° 24′ 25″; Long. 79° 1′ 20″.—A deposit of ore similar to the above was discovered by Mr. W. T. Blanford in the year 1872 at Kodaigowhan, 20 miles to the west of Munsur.

Berar Wun District: MALAGARH.—An impure ore of manganese has been described by Mr. Hughes[1] as occurring in botryoidal masses in the red clays of the Kamthi series round Malagarh. Its composition was as follows :—

Manganese oxide	44·6
Iron and alumina	6·8
Sand and clay	40·1
Loss on heating	8·5
	100·0

Nothing is known certainly as to the abundance of this ore, but from its described mode of occurrence the quantity to be found in a given number of cubic feet of rock would probably be very inconstant. As to its value the high percentage of impurity would perhaps render it unusable, and the amount of available oxygen would probably be incon-

[1] Records, G. S. I., Vol. VII, p. 125.

siderable, but the amount of this cannot be estimated from the above without the exact nature of the oxide is first known.

Amraoti District: PEEPUL COTTAH OR PIMPUL KOONTA, Lat. 21° 16′ N.; Long. 78° 4′ E.—It seems advisable to place on record here the circumstances connected with a discovery of specimens of manganese ore containing 80 per cent. of oxide of manganese at the above locality, as the circumstance was considered to be of importance at the time and gave rise to no little correspondence.

The result of the enquiry which was set on foot by the local officials was that the broken fragments of ore which had been found at a short depth beneath the surface inside the village had been brought from some unknown locality by the former inhabitants.

Rewah: BASI.—An impure manganese from Basi, in the South Rewah coal-field, which was obtained by Mr. Hughes, contains a large amount of insoluble matter, some iron, and a trace of cobalt. According to Mr. Mallet it appears to be an impure psilomelane.

Rajputana: Alwar State: BHANGARH, Lat. 27°. 7′; Long. 76° 22′.—In the iron mines at Bhangarh a mixture of limonite, magnetite and oxide of manganese is found, according to Mr. Hacket,[1] which contains 59·67 per cent. of iron and 12·7 of manganese.

Bundi State: DATUNDA, Lat. 25° 27′; Long. 75° 30′.—Small veins of oxide of manganese occur in fault rock near Datunda; according to Mr. Hacket these have not been worked.

Bombay: Dharwar District: WODOORTI.—At this locality, which is in the Kappatgode range, Captain Newbold[2] visited some old excavations, which, according to his informants, had been made by the agents of Hyder and Tipu in the search for coal (?). He found among the metamorphic strata there a dark rock, which was internally of a bluish-black hue, tough and powdery under the hammer. It contained numerous veins and nests of a shining foliated mineral of an iron-grey colour, &c. He concluded that the mineral was black oxide of manganese in combination with iron, and probably a little sulphur and alumina. There does not appear to be any recent account of this deposit.

British Burma: Tenasserim District: THUGOO.—Captain Tremenhere,[3] in the year 18[illegible]1, described the occurrence of manganese ores at three localities in the vicinity of the Great Tenasserim river. These are situated respectively on the bank of the Thugoo stream, which enters the

Records, G. S. I., Vol. X, p. 91.

Jour. Roy. As. Soc., Vol. VII, p. 212; Madras Jour. of Lit. and Sci., Vol. XI, p. 44.

Jour. As. Soc. Bengal, Vol. X, p. 852; Cal. Jour., Nat. Hist., Vol. III, p. 55. Selections from Records, Bengal Government, No. VI, p. 12.

Tenasserim 17 miles below the coal site, on the Therabuen stream, 5 miles above the Thugoo, and from an intermediate spot where the Great Tenasserim intersects an outcrop of the ore. No opinion could be formed as to the extent of the deposit owing to the scarcity of stream sections, and the thickness of the vegetation, but it was thought to be not improbable that a bed of ore, several square miles in extent, existed, which united all these localities, but even without this sufficient could be obtained, it was believed, at the three localities; the ores consisted of the black and gray oxides and wad. The Rev. Mr. Mason states that he has seen manganiferous iron from one of the islands south of Mergui.[1]

Upper Burma.—Among some minerals received from Ava and forwarded by Major Burney, Mr. J. Prinsep[2] found a sample of black oxide of manganese with earthy fracture and shining mammillated surface. Nothing is known as to the mode of occurrence of this ore.

Chromium: General Remarks.—This metal is found in chrome ochre, consisting simply of the sesquioxide more or less pure, and in chromite, which is the same in combination with iron protoxide. It is also a constituent of crocoisite or lead chromate, and in small quantities it affords the colouring principle of many minerals, as emerald, serpentine, olivine, &c.

The compounds of chromium, which are largely used as pigments, are chiefly prepared from chromite. Of these, the yellow chromate and the red bichromate of potash are perhaps the best known; from them chromic acid, the green oxide of chromium, the blue oxide of chromium, chromate of lead and other compounds are obtained; these include among them some of the most brilliant and valuable pigments among those which are employed in the arts.

Chromite or chromic iron, wherever it has been found, usually occurs in veins or masses in serpentine or in magnesite, and to this mode of occurrence the only known cases in India completely conform.

Serpentine does not occur in many parts of India, and the localities where chromite has been discovered are very few. In the peninsula the recorded details as to its mode of occurrence in the Salem district are the most complete; in the Himalayas the most important deposit is in Spiti.

Madras.—The principal source of chromite in the Madras Presidency is situated in the Salem district. Captain Newbold[3] refers to more

[1] Natural Productions of Burma, p. 48.
[2] Jour. As. Soc. Bengal, Vol. I, p. 15.
[3] Jour. Roy. As. Soc., Vol. VII, p. 169.

or less definite information as to its occurrence at Yedichicolum, on the Cauvery in Trichinopoli, and in the vicinity of Hoonsoor in Mysore. Dr. Balfour[1] states that samples from Bangalore and Vizianagram were exhibited at the Madras Exhibition.

Salem District: CURPUR OR CARUPUR, Lat. 11° 43′; Long. 78° 11′ E.—In one of his valuable papers on the mineral resources of Southern India, Captain Newbold gives an account, which is illustrated by a diagram of the mode of occurrence of the chromite in the mines at the above locality. It is stated to have been first discovered by Mr. Heath and afterwards by Mr. Fischer, and mines were opened by the Porto Novo Iron Company. It is believed that a considerable quantity of the ore was exported to England, but after the first 100 tons had been extracted mining became difficult, and finally it was found that the export of the crude ore did not pay.

The principal rock in the low hills at the south-west base of the Shevaroy hills, where the mines are situated, are hornblendic mica and talcose schists penetrated by dykes of basalt and layers of serpentine, which last is intersected by a perfect network of veins of magnesite. The chromite occurs very irregularly in these veins in lenticular masses of various shapes and sizes; one block was said to weigh a couple of tons. At a depth of from 50 to 60 feet water became troublesome in the mines. It is not surprising, therefore, that mining became too expensive to be continued with profit, there being no certainty as to the proportion which the chromite bore to the mass of rock which had to be removed. At the same time the demand for this ore was by no means unlimited, and the immediate effect of throwing the Indian ore on the London market is stated to have been to cause a fall in the price.

A short account of the appearance of the deserted mine, when seen by them in 1861, is given by Messrs. King and Foote.[2] At that time the interior was inaccessible.

Mr. E. Solly's report on the Salem ore, as quoted by Captain Newbold, was that a tolerably pure sample yielded 49 per cent. of chromic oxide, equal to about 57 per cent of chromic acid, or cent per cent. of chromate of potash. The ore was in fact as good as could be desired, and the only question to settle was whether it could be obtained in quantity equally pure at a moderate cost.

So long as England can obtain the crude ore from Scotland and Styria in sufficient abundance, it is not likely that it will pay to send

[1] Cylopædia, Art.—Chrome iron ore.

[2] Mem., G. S. I., Vol. IV, p. 93.

any from India. And it is not at all probable that a local manufactory of the chromic salts would prove a profitable undertaking.

Punjab: Kulu.—Mr. Calvert[1] states that certain quartzose rocks in the valley of the Parbatti, between Mateara and Kusole, are stained with the emerald green oxide of chrome. Although the colouring matter may be due to the presence of chromium, it seems probable that the actual mineral is a silicate of magnesia.

Spiti.—Samples of chromite, weathered out from serpentinous rocks, were found by Mr. Mallet[2] among the debris of the comparatively level ground which borders the Hanle-chu river, but none was obtained *in situ*, though, from the size of the fragments, it was concluded that it may very probably occur in quantity. The mineral generally had a more or less distinct crystalline structure, sp. gr. 4·208. Some specimens were traversed by veins of another chromic mineral, which resembles ouvarovite, but differs from it in composition, as is shown by comparative analyses which Mr. Mallet quotes.

[1] Kulu, p. 75.
[2] Mem., G. S. I., Vol. V, p. 167.

CHAPTER VIII.

IRON.

Iron: General Remarks.—An idea of the abundance and extent of iron ores in India can be most clearly conveyed by a systematic statement of their mode of occurrence and distribution in the respective formations of the geological sequence. Thus, to begin with the peninsular area, we find that magnetite occurs in beds or in veins of greater or less extent in most of the regions where metamorphic rocks prevail. In some places, as in the Salem district, in the Madras Presidency, the development of this ore is on a scale of extraordinary and almost unparalleled magnitude, whole hills and ranges being formed of the purest varieties of it. In many cases it would seem that these deposits are not lodes, but true beds, in the same sense as are the gneissose and schistose rocks with which they are associated. Similarly, in the Chanda district, there are enormous deposits of specular iron or red hæmatite, with which magnetite also occurs. To the abundance and wide-spread distribution of these ores in the oldest rocks is no doubt to be attributed the fact of the frequent recurrence of considerable deposits, and the general dissemination of ferruginous matter, which more or less characterise the sedimentary rocks of all subsequent periods.

In the submetamorphic or transition rocks again, bedded magnetite is known to occur in some localities, and it is probably more abundant in these rocks than is generally supposed, as when weathered, and when not

minutely examined, it might pass as a meta-diorite. Along faults and fractures, both in the metamorphic and submetamorphic rocks, very considerable veins of limonite are to be found in many parts of the country, as in Kadapah, Karnul, Manbhum, and in Jabalpur, &c. The rich ores of Central India are principally found as hæmatites in the Bijawar or lower transition series of rocks.

In the great Vindhyan formation ferruginous matter is commonly disseminated through immense thicknesses of beds, giving rise to the prevailing red and brown tints which characterise the rocks; but in all cases where the ores are sufficiently concentrated to be workable the deposits occur as veins, not as beds.

In the Gondwana system of rocks, the lowest group, the Talchir, is believed to have been formed by the deposition of its materials from floating ice, and, in it, the absence of ferruginous matter is conspicuous; but in the next succeeding group, the Barakar, although many of the beds of conglomerate, sandstone and shale are almost free from iron, in others concretionary masses of limonite are abundant, and in some of the coal-fields clay iron ores or siderite, altered more or less into limonite, occur bedded in sufficient quantity to be of considerable importance. Perhaps the most noteworthy instance of this is in the Aurunga field, in Palamow. In all the coal-fields, it is believed, these ores, whether of concretionary or bedded character, are used by the native smelters, but the unaltered carbonates are rarely if ever employed, the native furnaces being, apparently, unsuited for their reduction.

The next group, the so-called ironstone shales, is not represented beyond the limits of the Damuda valley, and as a source of iron ore its development is at its maximum within the limits of the Raniganj coal-field, where there is an inexhaustible supply of readily accessible ore. This ore, which originally existed in the form of black band or siderite, has been to some extent altered into limonite towards the surface, but to the deep it would doubtless be all found in its original condition. In the coal-fields to the west of the Raniganj, although the ironstone shale group is present, the amount of good ore is nowhere so abundant.

In the next succeeding group, the Raniganj-Kamthi, the distribution of ore is somewhat unequal. In typical Raniganj rocks ferruginous matter is scarce, and often wholly absent, but in their western equivalents, the Kamthi group, the amount of disseminated ferruginous matter is considerable and sufficient to produce all pervading red and brown tints. In these rocks too there are segregated masses and thin layers of iron ore, which are occasionally, but perhaps less commonly, than are those in the Barakar rocks, made use of by the natives for smelting purposes.

The lithological characterstics of the succeeding groups of the Gondwana series, in so far as they refer to the presence of iron ores, are almost precisely similar to those just described. The proportion of white rocks, whether shales or sandstones, in which the presence of ferruginous matter is not directly apparent, is comparatively small, and the segregated plate-like masses of ferruginous matter, which stand out in relief on the weathered surfaces of sandstones and conglomerates, are to be found in several of the groups.

Next in the sequence of peninsular formations are the cretaceous rocks. In Southern India, in the Trichinopoli district, these contain nodules of iron ore in some abundance, and formerly, when fuel was more abundant than it now is, they were smelted to a considerable extent by the inhabitants.

The Deccan trap, which is believed to have been poured forth in vast flows at the close of the cretaceous period, and perhaps continued to be so into early tertiary times, includes a vast amount of iron ore disseminated for the most part in minute crystals of magnetite; but occasionally it occurs in nests of segregated hæmatite, and, more rarely, in layers which pass into ferruginous earth or bole.

The beds of rivers which traverse this trap not unfrequently contain magnetic iron sand, which may be collected in sufficient quantity for the requirements of native furnaces; but, as in the regions where this trap occurs, the source of ore next to be described is generally also to be found, recourse is more commonly made to the latter than to the former.

The age and origin of the laterite have been fully discussed in Part I. of this work, and its richness in iron, which is its leading lithological characteristic, has been specially noticed. Certain segregated bands, which not uncommonly occur toward the base of the beds of laterite, are often prolific sources of an easily worked brown hæmatite, which sometimes includes a high percentage of metal. Lateritic ores have been worked by the native smelters in different localities scattered over the whole of India; and at Bepur in Malabar, and at Mahomed Bazaar in Birbhum, they have been used in furnaces by British companies.

Lastly must be mentioned the detrital ores of sub-recent age, which are derived from the break-up of the above deposits, and from various superficial accumulations of ferruginous matter. These being in general easily obtained, and being more or less soft and decomposed, are frequently preferred by natives to the harder and more refractory ores *in situ*, which are often difficult both to mine and to reduce.

In the extra-peninsular regions, in groups of rocks, many of which are of quite different ages from those found within the limits of the

peninsula, iron ores occur locally in considerable abundance. The principal sources of these are the tertiary rocks, as willbe seen from the following detailed accounts; but in the North-west Himalayas, and also apparently in Afghanistan and Burma, there are considerable deposits of ore in the older metamorphic rocks.

Practical men have sometimes spoken of the native furnaces and method of working contemptuously, as being merely objects of curiosity. On the other hand, some writers have given the operations of the natives the benefit of their close attention, and have submitted them to very close analysis. It has been said of the natives, that though they possess the art they know nothing of the science; but in this respect they do not differ from the artizans of many crafts in more civilised countries, and the introduction of scientific guidance in European iron factories is by no means universal at the present day, and is probably nowhere of great antiquity. In many cases it has been left to modern chemists to explain the *rationále* of processes which have been in practice for centuries. Chance combinations and the rule-of-thumb were formerly the guiding stars rather than science in all departures from old methods. The struggle for existence has of late years rendered it necessary, however, for all large iron and steel works to include a chemist or analyst on their permanent staff.

As will be abundantly shown in the course of the following pages, the manufacture of iron has in many parts of India been wholly crushed out of existence by competition with English iron, while in others it is steadily decreasing, and it seems destined ultimately to become extinct. For this reason alone, if there were no others, the native process is worthy of full notice here, but there are other strong reasons why it should be described, and which demand for it our respectful consideration and admiration. As in the animal world, the process of degeneration has produced forms which are but dwarfed representatives of their earliest progenitors, so it is with the rude smelting furnaces of the natives, which, though they may not now in some cases be much superior to those which the Celts erected on hill-tops to catch the passing breezes, are probably to a great extent the lineal descendants of a system of iron manufacture, which in the earliest times of which we have any record must have been on a scale of considerable magnitude.

The famous iron pillar at the Kutub, near Delhi, indicates an amount of skill in the manipulation of a large mass of wrought-iron, which has been the marvel of all who have endeavoured to account for it. It is not many years since the production of such a pillar would have been an impossibility in the largest foundries in the world, and even now there

are comparatively few where a similar mass of metal could be turned out.

The exposed portion of this pillar stands 22 feet above the ground, and tradition ascribed to it a prodigious length under the surface. Even after excavations were made, it was stated to be 35 feet, but subsequent examination, made under General Cunningham's directions, proved it to be only 20 inches, so that the total length is 23 feet 8 inches. Just below the surface it expands into a bulbous form, 2 feet 4 inches in diameter, and it rests on a gridiron of iron bars which are fastened with lead into the stone pavement. The diameter of the pillar itself is 16·4 inches at base and 12·05 inches just below the capital, which is 3½ feet high. The above dimensions indicate a weight exclusive of the capital and the base of 5·7 tons, so that the total weight must exceed 6 tons.

Analyses of the iron have been made both by Dr. Percy, late of the School of Mines, and Dr. Murray Thompson, of Rurki College, who have found that it consists of pure malleable iron without any alloy. It has been suggested that this pillar must have been formed by gradually welding pieces together; if so, it has been done very skilfully, since no marks of such welding are to be seen.

By those especially interested in the subject reference should be made to the discussion of its age by Mr. Fergusson.[1] From the form of the letters in the inscription which it bears, various views as to its age have been suggested. Mr. Fergusson believes that A.D. 400 is not far from the truth. We have in this pillar therefore, which, though it has been always exposed to the atmosphere, shows no sign of rust, the most complete testimony of the skill and art of the Indian iron-makers 1,500 years ago. Forged iron bars of large size have been found also in temples of considerable antiquity in many parts of India, but especially in the south; and enormous cannons used to be made in Assam.

Referring again to the analogy drawn from the animal world—as we find in certain animals aborted or partially extinguished organs which point to certain functional powers having been possessed by their progenitors, similarly, if we take a survey of the systems of iron manufacture, as practised by the natives of India, we meet here and there traces of what may be the remnants of higher systems of working than those now existing. These are quite independent of obvious local differences as to the forms and size of the furnaces and the bellows, or differences in the nature, size, and subsequent treatment of the bloom. First in importance is the manufacture of cast-steel, in crucibles, which attracted so much notice many years ago. For a time Indian *wootz* or steel was in considerable

[1] History of Indian and Eastern Architecture.

demand by cutlers in England. Its production was the cause of much wonderment and became the subject of various theories. The famous Damascus blades had long attained a reputation for flexibility, strength, and beauty before it was known that the material from which they were made was produced in an obscure Indian village, and that traders from Persia found that it paid them to travel to this place, which was difficult of access, in order to obtain the raw material. The circumstances connected with this manufacture will be found set forth in the following pages, and to the means by which the carbonization of the iron was effected the reader's special attention is directed, as it seems to point to synthetical knowledge having been possessed by the inventor of the process. There are reasons for believing that 'wootz' was exported to the west in very early times—possibly 2,000 years ago.

Although in the typical Indian furnace the ore is in direct contact with the fuel, and is reduced, without the addition of flux, to a pasty mass, complete liquefaction not taking place, there are still localities in which, separately, there are departures from this rule in one or other detail. In Kattywar the furnaces are described as being of a form approximating in character to reverberatory furnaces, for in them the flame produced by the blast over the ignited fuel played over the ore which was piled by itself and not mixed with the fuel. In Waziristan, on the testimony of Dr. Verchere, a flux of limestone is added to the charge. Unconsciously this is done too at one locality, if not in others. At Tendukhera, in the Narbada valley, where iron of superior character is produced, the ore contains intermixed with it a good deal of the matrix rock, which is limestone. Lastly, it is distinctly stated that in the large furnaces in Birbhum, the iron was produced in a fluid condition and was run into pigs, which were subsequently converted in open hearths into malleable iron.

As examples of furnaces having special modifications, those in Upper Burma, in which the artificial blast is wholly dispensed with, may be noticed. Whether it is true that iron is ever smelted in open hearths may well be doubted, though testimony to that effect is not wanting, but it is probably due to a mistake. The writer has been more than once informed that lumps of malleable iron were regularly found in a certain hilly region, and were brought to the bazaars for sale. Now those lumps of supposed natural or native iron would have been found, had they been first carefully examined by those who told the story to include masses of partially consumed charcoal; they were in fact blooms from small native furnaces, and could naturally therefore be worked up by simple heating and hammering into useful iron.

Besides the competition which has been alluded to above as causing the gradual extinction of the native industry, there is another fact which tends to produce the same result, and that is the increasing scarcity of fuel. In some cases, where the fuel has all been used in the neighbourhood of furnaces, the necessity of bringing it from great distances has steadily diminished the margin of possible profit. In others, where Government has stepped in to preserve the forests from destruction, the burning for charcoal has been forbidden, and the smelters have had to betake themselves to other regions not yet reserved, or to other means of obtaining a livelihood; but it is not easy for the artizan of any country to change his trade, and in India it is hedged in by greater caste difficulty perhaps than elsewhere. It is for this reason that one finds the iron smelters in many regions the hardest worked, but poorest, among the population. The iron is sold at a high price, but the bulk of the profit goes to the traders through whose hands the metal passes. The amount of iron produced bears but a miserable proportion to the labour, time, and material expended.

In some cases the consumption of charcoal fuel for the production of finished iron is as 14 tons of the former to 1 ton of the latter. This is perhaps exceptional, but is possibly sometimes exceeded, and whatever charcoal is used, represents a proportionately high amount of timber, since the methods of preparation are often extremely wasteful.

Where there are not extensive jungles to draw from, or where the timber is sufficiently accessible to be used for other purposes, the compulsory closing of furnaces is rather a matter of policy than a fit subject for regret; but, on the other hand, wherever there are extended tracts of unreserved jungle it does not very much matter, especially since the unrestrained annual jungle fires consume a much greater amount of timber than any number of charcoal-burners could do. The timber used by them is, however, almost invariably the best that the particular jungle affords, such as sal, teak, &c.

Propositions have been made from time to time to adopt a modification of the native system, which, while retaining the form of furnace, would economise labour by supplying the blast from an engine. It has been also suggested that by employing the waste loppings of Government reserve forests, charcoal might be had at a nominal cost; but it may perhaps be doubtful whether indiscriminate loppings would yield charcoal suitable for the purpose. It is certainly the idea of the natives that the quality of the iron varies with the nature of the timber used for making the charcoal, and in many places charcoal from the bamboo is alone used for refining the iron. This selection is probably due to experience

rather than to mere chance or prejudice. Supposing, however, that this would not be found to be the case, it is conceivable that a large amount of charcoal iron might be manufactured by such a system in certain localities, and could native capitalists be got to take up the matter, on being secured a constant supply of fuel, it might prove very profitable.

Defects in the quality or quantity of the fuel have been no doubt among the principal causes of the failure to make iron profitably on the English system. In the case of the Bengal iron works at Barakar this was less felt than in others. The coal, though it might easily have been better, answered fairly well. In Chanda, however, it may be taken as having been fully demonstrated that the coal is too impure to be placed in direct contact with the ore in reducing furnaces. As regards the use of charcoal, the effect has been to denude large tracts of country wherever large furnaces have been established, as at Bepur and Porto Novo in the Madras Presidency, at Mahomed Bazaar in Birbhum, and also to some extent in Kumaun. The result of bringing a large number of people together anywhere in India is of itself destructive to forests, owing to the amount of fuel which each individual makes use of for domestic purposes.

It has been most clearly shown that without planting and strict conservancy the natural recoupment of Indian forests, at least in the drier northern regions, is too slow, even if it takes place at all, to keep up the supply of timber for an unlimited number of years.

In spite then of the abundance of ores of the richest character, the question as to the possibility of manufacturing iron profitably on the large scale becomes narrowed by existing conditions. In anticipation of the details given below, it may be said that by ordinary blast furnaces and Bessemer converters[1] adapted to the removal of an excess of phosphorus, it is believed that in the Raniganj field iron and steel of high qualities

[1] Recent discoveries have had a most important result in minimising, if they do not wholly remove, the hitherto insuperable difficulties in the manufacture of steel from pig iron containing an injurious per centage of phosphorus. Among these discoveries that which has been patented by Messrs. Thomas and Galchrist is perhaps the most important. Hitherto, in the Bessemer converters, the lining of silicious bricks kept up an acidic condition of the slag; at the high temperature involved in the process this rendered oxygen inoperative as regards the phosphorus, which therefore remained combined in the metal. By means of a durable and refractory brick lining made of basic materials a basic condition of the slag, without excessive waste or injury to the metal or lining, has been secured, the result being that under the conditions thus afforded oxygenation of the phosphorus does take place and the phosphoric oxides, combining with the bases and forming phosphates in the slag, render it possible to draw off the steel with but an unimportant trace of phosphorus remaining. The bricks are made of an aluminous magnesian limestone; it is not improbable that the Panchet limestone might be made to answer the purpose.

might be manufactured under proper management, at an average cost which would probably admit of their underselling English metal in Bengal. The same remarks may apply too hereafter, when communications are improved, to the Palamow field, but the conditions there are perhaps not quite so favourable. In Chanda, as has been above said, ordinary blast furnaces are inapplicable owing to the badness of the fuel; but it is possible that, by other methods of reduction, Chanda would be in a position to supply the Central Provinces and parts of Bombay with iron at an average rate slightly lower than that paid for English iron. The same remarks may perhaps be extended to some of the localities in the Narbada valley. But as regards the rest of India, with the doubtful exception of Upper Assam, there does not appear to be any solid ground for hope that iron, under existing conditions, can be manufactured profitably. This opinion is founded upon careful analysis of all that has been done to give the matter a fair experimental trial at a number of places, the particulars of which will be found in the following pages.

Even with regard to the places above excepted, it seems probable that the margin of profit will always be a small one, and it will oscillate much as does the price of English iron in the Indian market. The effect of the improvements in English manufacture will almost certainly result in a further diminution of the native manufacture which still exists in many tracts simply because the soft charcoal iron is more malleable, and therefore more manageable by native blacksmiths, than is the less pure English iron. There is at present a large sale for Swedish and Welsh bar in India.

In reference to the competition between Indian-made iron and that from Europe there are several facts which operate prejudically against the wide employment of the former. In Europe the iron produced in different localities, and even in different factories in the same localities, varies very much in qualities and properties. Sometimes, in consequence of difference in the materials, and sometimes owing to peculiarities in manipulation, iron possessing special properties is produced, and thus it is that particular districts and particular firms have become identified with the production of certain qualities of iron best adapted for particular purposes, and accordingly consumers of iron go to one firm for one quality and to another for a different one, according to the precise purpose for which the iron may be required.

In India the best that could be hoped for by any one firm having constantly the same materials to deal with would be to be able to turn out regularly a particular quality, which would steadily reach a recognised standard; so that consumers of iron in India would probably still

find it necessary to order from Europe iron having particular qualities for special purposes to which the Indian iron was not applicable. That a single factory could ever supply all the different qualities of iron required in any one province in India is not to be expected; but if rails of good quality and ordinary castings could be produced, a single factory might supply all the requirements in those articles within a certain radius; supposing the factory, for instance, to be situated inland in Bengal, it is not likely that its iron could compete with English iron at the ports of Madras and Bombay. Under exceptional prices and circumstances it might do so, but the industry to be successful must be supported by a steady demand for its manufactures.

Supposing, on the other hand, that iron factories were established in the different provinces of India, their immediate effect would probably be to lower the price of English iron, since India is one of England's largest customers, and thus the margin of profit would probably be swept away, and the manufactures of the Indian factories would be undersold till such time as they were driven out of the market and the factories of necessity closed. Were there any probability of the Indian factories being able to produce iron at such a low rate as to defy competition this could not happen, but the experience, so far as it goes, tends to show that the possible margin in this direction must be a narrow one.

In England, where the factories represent the outcome of the accumulated experience of many years, and where the surrounding population has been born and bred to the work, casualties of whatever nature need not cause, and generally do not cause, more than a temporary stoppage of work; but in India, loss of life or injury to machinery could not fail to be productive of serious and prolonged delay. Where, in England, a score of competent men might be found at a moment's notice to carry on charge of any department, of which the incumbency, from whatever cause, became vacant, it might be difficult to find one in India. Injuries to important pieces of machinery always cause much greater delay in India than in England. Of course, it may be said that by having a reserve of foremen and machinery the evil consequences of casualties might, to a great extent, be minimised, but such a reserve would add materially to the working expenses.

Of all the places in India where iron-making is possible, there is none where these difficulties would be less felt than in the Raniganj field, owing to its vicinity to the population and foundries of Calcutta and the coal mines and the railway population at Assensole.

Much has been written both for and against the idea of Government itself undertaking the manufacture of iron. Although the policy in this

respect has oscillated from time to time, the general character of what has been done has been either to expend money upon experimental trials, to subsidize companies, or to direct the different departments to obtain their supplies, as far as possible, from local sources, and thus aid the efforts of companies.

It seems to be not improbable that had the Government started the manufacture of iron on an extended scale at the time of the opening up of the railways, great benefit would have accrued to the State. That it would have been possible, politically speaking, for any Government to have done so continuously may be doubted, owing to the opposing interests involved; but that had there been a department of the State, similar in its organization to the Forest or Salt departments, it is almost certain that the effect of establishing factories for iron manufacture throughout India would have been to keep vast sums of money in circulation in the country, and to have given employment to large numbers of people who now crowd the land.

In a suitably officered department there would be a margin of officials to allow for leave and casualties, and what is perhaps of more importance to success, the managers of individual factories would be upheld in their authority by a prestige which the managers of companies do not possess. A spirit of independence of action soon grows up among European employés, and it requires very exceptional qualities in a manager, who has no local influence and who cannot directly claim the aid of those who have, to enable him to keep mechanics steady and attentive to their business, as Government servants are prohibited from taking part in the direction of companies. No industry in India requires the same amount of arduous and unremitting personal labour as that required from iron smelters and puddlers.

These remarks are made with special reference to what is known to have taken place at Bepur and Dechauri, not to mention other localities.

The following statement shows the quantity of iron which has been imported into India during the past few years by the State; and in Appendix A. it will be seen that the value of iron imported by the general trade has varied during the same period from Rs. 77,78,824 in 1873-74 to Rs. 1,22,93,847 in 1879-80. The total value of imported iron, exclusive of that imported by the State between the years 1867-68 and 1879-80 inclusive, amounts to the sum of Rs. 15,62,10,253, or at par exchange say £15,621,025, a large portion of which sum might have been kept in India had the iron manufacture proved a practical success.

Amount imported by the State[1]

	Tons.	Cwt.
1873-74	117,430	9
1874-75	91,829	4
1875-76	69,247	
1877-78	201,658	9

The following statements of the average prices of English pig iron in the Calcutta market for the last 30 years will convey some rough idea of the price at which the same article ought to be produced in India in order to hold its own. The average cost of No. 1 iron, it is to be understood, ranges from Rs. 8 to Rs. 20 above the figures given below, which are for all qualities or numbers combined :—

1850 . .	30½	1860 . .	35	1870 . .	33
1851 . .	33¾	1861 . .	38	1871 . .	34
1852 . .	42⅛	1862 . .	37	1872 . .	47
1853 . .	70	1863 . .	31	1873 . .	81
1854 . .	59	1864 . .	30	1874 . .	77
1855 . .	65⅛	1865 . .	29	1875 . .	60
1856 . .	69½	1866 . .	47	1876 . .	42
1857 . .	54⅝	1867 . .	46	1877 . .	35
1858 . .	43	1868 . .	41	1878 . .	28
1859 . .	56	1869 . .	34	1879 . .	39 ?
Averages for periods of ten years	52·4		40·8		47·6

The average value for the whole period is, therefore, Rs. 46·7.

Madras.—The following abstract of information regarding Madras iron ores was drawn up before a copy of Dr. Balfour's report on the subject became accessible to the writer. It has not been convenient to re-cast or increase what has been written, so that for information on some minor details, and regarding some districts not mentioned below, reference should be made to that report.[2]

Travancore State.—There does not appear to be any accessible information on the subject of the iron ores and manufacture of iron in Travancore, but it may not be out of place to refer to a paper by Mr. J.A. Broun, F.R.S.,[3] on the magnetic properties of the magnetite-bearing rocks in that State, as it is a contribution to the natural history of an ore, the development of which in India is on a scale of, probably, unequalled magnitude. The observations were made on the Moocoonoo-

[1] Supplement to *Gazette of India*, 1878, p. 1527; and 1879, p. 753.
[2] Madras, 1855.
[3] Report of British Association, Oxford, 1860, Sections, p. 24.

malley hill, round the base of which there is laterite; but the main mass of the hill is formed of syenites and granites with magnetite. The following were the conclusions arrived at:—

(1) The rock fragments have determinate magnetic axes;
(2) Broken fragments resemble broken magnets showing opposite polarities at the two surfaces of fracture;
(3) The magnetic axis varies from place to place within small distances;
(4) The action of the whole hill on magnets freely suspended at moderate distances is nearly imperceptible, the opposite directions of the magnetic axis in the rocks rendering the total action nearly zero;
(5) As in some cases the north end of the magnetic axis was found to the southward, we cannot suppose that the magnetism of the small magnets has been due to the inducing action of the earth in their present position, or since the rock mass became solid;
(6) The directions of the magnetic axis have no relation to the lines of division (joints) of the rock masses;
(7) The magnetic force of the rock masses varies with temperature like that of steel magnets.

Madura District.—Iron ores are said to be very generally distributed throughout this district. Formerly, according to Mr. Foote,[1] ores obtained from beds of lateritic conglomerate used to be smelted in some quantity, of which large heaps of slag scattered over the country afford evidence; but the industry is now extinct. Only one deposit of magnetic iron was seen. It is situated in gneissic rocks, about a mile north-east of Mallampatti, a village in the Pudukotai State, 19 miles north-west by north of Pudukotai. The outcrop was badly seen, but the debris from it was abundant.

In the Madura District Manual[2] it is stated that iron ores occur near Kottampatti, and in the Sivagangei zamindari and in villages near the bases of the mountains. The Tenkarei country was noted for its iron ore.

Trichinopoli District.—Mr. H. Blanford,[3] in his description of the cretaceous rocks of Trichinopoli, mentions that they contain ferruginous nodules, which were formerly smelted, as is proved by mounds of slag; but owing to the scarcity of timber the industry is now almost, if not

[1] Records, G. S. I., Vol. XII, pp. 147-157.
[2] Page 29.
[3] Mem., G. S. I., Vol. IV, p. 216.

altogether, extinct, and the people obtain their supply of iron from the adjoining Salem district.

Magnetic ores occur, it is believed, in the northern parts of Trichinopoli; but these are of trifling importance and extent as compared with those of Salem.

Coimbatore District.—The iron industry in this district appears to offer no points for special remark. Some information on the subject will be found in Dr. Balfour's report, and Dr. Buchanan appears to have visited some parts of the district and described the furnaces. The principal ore is magnetic sand.

Salem District.—The development of magnetic ores in the Salem district is among the most remarkable facts connected with the geology of India, whether the extent, thickness, or number of the beds be considered. Messrs. King and Foote have given an account[1] of their distribution, and for convenience of description they divide them into groups as follows:—

1st.—The Godumallay group, east and north-east of Salem;
2nd.—The Tullamullay Kolymullay group;
3rd.—The Singiputtay group;
4th.—The Tirtamullay group;
5th.—The Kunjamullay group.

Owing to the persistency of the beds over long distances, they often afford an admirable clue to the geological structure of the region. In some cases they form the culminating ridges of ranges of hills. They are occasionally from 50 to 100 feet thick, and where steeply inclined or vertical, an enormous extent of ore is laid bare to view in cliffs and precipices which are several hundreds of feet high. The quality of the ore varies a good deal, and it is sometimes much mixed up with quartz. Ore is however, in short, to be obtained in this region of the best quality, and in quantities to be estimated only in thousands of millions of tons, but the scarcity of fuel is the great drawback to its being made available. The natives obtain ore either as sand on the surface or from shallow pits. It is not quite clear from the accounts available whether *wootz* was manufactured to any great extent from these ores, but the probability is that it was.

In the Appendix to Messrs. King and Foote's report there is a very full account of the Kunjamullay ores, which is illustrated by a plan, elevation, and view, to which the reader is referred for further information. Even the native manufacture was decreasing from various causes

[1] Mem., G. S. I., Vol. IV, pp. 57, 152, 379.

when they wrote, and the imports of English iron into the Trichinopoli, Salem and adjoining districts was increasing.

Porto Novo.—Although Porto Novo is situated in South Arcot it may be most conveniently referred to here, as the iron ores which were used at the furnaces there were obtained in Salem. The large demand for Indian steel in England led to the formation, in the year 1833, of a Company called the Indian Steel, Iron and Chrome Company, by Mr. Heath, who obtained a Government advance for the purpose in 1825. It is stated that this company produced excellent steel, and, in order that it should reach the market free from any defects which might injure its reputation, they had an establishment at Chelsea, through which it was tested and passed before being sold. Having succeeded, they disposed of the Indian works and established themselves in Caermarthen, where they manufactured a superior quality of charcoal iron.

The leasehold rights of the company, which were acquired by another company, extended over four districts, namely, South Arcot, Coimbatore, Malabar, and South Canara. Foundries were set up at Porto Novo to work the Salem ore, at Palampati near Salem, and at Bepur in Malabar, where the ore was laterite.

Mr. Sowerby gives an account of a visit which he paid to the Porto Novo works in 1859. He states that the iron ore had to be brought from many miles distant in the interior, and owing to all the jungle having been cut down, and the land cultivated, the charcoal had to be brought from a distance of 25 miles. The flux was prepared, he believed, from sea-shells. The principal work done had been in castings, but some pig had been sent to England and had commanded a good price for conversion into steel, and a large quantity of it was used in the construction of the Britannia tubular and Menai bridges. The iron would, it is said, have commanded a good price had the supply been regular, but it rarely realised more than from £7-10 to £9 per ton, while Ulverstone iron, which was no better if even so good, sold for from £10 to £12. There were difficulties about shipping it, and at the time of his visit there was a large stock of pig on hand. The furnaces were seldom, from one cause or another, at work for more than four months in the year, and the cost of management alone was thus raised from 10 shillings to 30 shillings per ton. Altogether the company appears to have never declared a dividend, and the concern was a steadily losing one.

About this time (1859) however, at a meeting held in Sheffield,[1] the value of Indian pig for steel manufacture was discussed. There had been some prejudice against the use of any description of pig whatever for

[1] Engineers' Journal, Calcutta, Vol. II, p. 274.

making steel, but this had been overcome. Mr. Brown, after various trials and experiments, had come to the conclusion that iron, as produced for file purposes, from Indian pig, was superior to any other in England, and that it had been proved to be superior to ordinary marks of Swedish iron for steel purposes. One manufacturer had bought over a thousand tons of Indian pig for railway tyres. The Chairman stated that he had been the first to make steel from Indian pig, and from that time it had been steadily making its way. He added his conviction that India would ultimately become one of the largest sources from whence Sheffield would draw her supplies of raw materials. The price at the time in the London market was then only £6-10, while ordinary English pig, it may be added, was selling in Calcutta at about Rs. 56-2-8.

It is to be remembered that the above pig was from Porto Novo, not from Bepur; having been made from magnetic iron ore, it was especially applicable to the manufacture of steel; but it may be doubted whether that which was sold at £6-10 ever repaid the cost of production and carriage.

Arcot Districts, North and South.—Iron ores are said to be abundant in South Arcot, in parts of the Trinomalai taluk, where the Porto Novo Company[1] had a factory. They also occur on the Kalrayan hills, particularly on the slopes below Chinna Tripatti, also near Ponparappi and Ravatnallur.[2]

Heyne[3] described the manufacture of iron at Zeragutty, near Satghar in Arcot, from what he believed to be titaniferous magnetic iron sand; the chief feature to be noticed in his account is the careful way in which the proportions of ore and charcoal seem to have been fed into the furnace; nine seers of sand produced five seers of iron, which must be regarded as a large percentage.

Malabar District.—Dr. Buchanan[4] during his famous journey through Mysore, Canara, and Malabar, noted several places in the last mentioned where iron ores occurred, and were worked. It is probable that some of these are no longer included within the restricted limits of the modern Malabar, but it will be sufficient to mention them here as they are referred to. At Colangodu there were four furnaces, in which black magnetic sand was used as an ore. At Velater there were 34 furnaces which belonged to a Mopla. The ore was derived from the very laterite which suggested to Dr. Buchanan the name. Being cut into bricks for building, the term *lateritis* suggested itself to him as an

[1] Selections from Records, Government of India, Vol. XXVI, p. 54.
[2] South Arcot District Manual, p. 373.
[3] Tracts, p. 189.
[4] Journey, Vol. II, pp. 386, 436, 494, 502.

appropriate title. This ore had to be prepared by washing in a trough, open at both ends, which was placed in a running stream. This washed ore was, perhaps, largely magnetic. The furnaces, of which admirable sections and elevations are given by Dr. Buchanan, were excavated in mounds of clay, 5 feet 4 inches high in front and 4 feet behind, and about 7 feet wide from front to back. The excavation for each furnace was 2 feet 11 inches wide and 2 feet deep, and was dug down from the top of the mound to the bottom; an arched cavity at the back, with a hole at its base, was then made and the structure surmounted with a chimney. The charge of ore was 2,160 lbs. and of charcoal fuel 1,890 lbs., of which some was not consumed during the 24 hours while the furnace was in blast; the yield of iron was from 246 to 384 lbs., or from $11\frac{8}{10}$ to $17\frac{8}{10}$ per cent., according to the success of the operations. It was of the usual character and was partially malleable though brittle. The bellows were leather bags, 18 inches high and 9 inches in diameter. One man worked a pair by clasping the slit flaps at the top; by alternately raising and depressing the bags the air was driven through a nozzle common to both bags. Each furnace required two pairs, and each pair required two men in order to relieve one another. The iron was sold at the rate of 7 shillings $7\frac{3}{4}$ pence per cwt., and the profits were considerable.

Several other furnaces are also alluded to as having been seen in this region. It now remains to notice an attempt to establish iron works on the English system at Bepur.

Bepur or Beypur.—As already stated in the description of the Salem district, Mr. Heath's concession included permission to establish iron works at Bepur. Unfortunately, no succinct account of the operations appears to be available, and the following detached facts have been culled from different sources. The first works which were established commenced operations in the year 1833;[1] how long they continued is not known, but there appear to have been a succession of companies whose object was to establish the industry. The ore used was, it is believed, derived from the local laterite. In 1857[2] the Gun-carriage Department reported favourably to the Home authorities on the iron for their purposes, but in 1859 the works were in a bad way, as Mr. Sowerby[3] states that he had received a letter offering the whole of the machinery for sale to the Kumaun iron works. Deficiency of fuel was supposed to be the cause of failure; there were no roads by which it might be

[1] Standing Information of the Madras Government, 1879, p. 229.

[2] Thornton's Gazetteer of India, Art.—Beypur.

[3] Selections from Records, Government of India, No. XXVI, p. 52.

brought from the inland forests, where timber was abundant, and consequently it was actually imported from Ceylon. Mr. Sowerby [1] met in Styria certain returned German workmen, who attributed the failure to another cause. They said it was too hot for them to work, and that it was impossible to get naked savages to do such work as puddling; if they themselves left for a few moments all went wrong and the natives would fall asleep. Mr. Sowerby thought that Englishmen would have done better. Subsequently, in 1861, the puddling appears to have been superseded by the introduction of a Bessemer's converter, but the resuscitation was only temporary and the works have been closed for some years.

Nilgiris District.—Iron ores occur in some abundance on the plateau and spurs of the Nilgiris. They appear to have been first described by Dr. Benza, in 1836.[2] Subsequently, Mr. H. F. Blanford,[3] in his geological report, gave an account of their leading characteristics. Hæmatite and specular iron are more common at the surface than magnetite, but from their mode of occurrence as bands in the gneiss and parallel to the bedding it seems probable that they were originally magnetite, which has become altered by atmospheric agency.

The most important masses of iron ore occur above the village of Karrachola, 1½ miles west of Kotagiri, and on a small spur of Dodabetta overlooking the Dhobi's village. At Jackatalla pure strings of hæmatite occur interfoliated with the gneiss. Charcoal fuel is too scarce on the hills to make it possible that by its means the ore could be smelted. It may yet come to pass that the Nilgiri peat or the charcoal made from it may be made applicable to this purpose. Dr. Percy, in his work on Fuel,[4] discusses the question of the suitability of peat for metallurgical purposes, and mentions that peat charcoal had been so employed at Josefstadt in Austria, though he does not recommend its use, and states that the practicability of making good peat charcoal economically has still to be decided by experience.

In various parts of the Nilgiris decomposition of earthy iron ores have given rise to ochreous deposits suitable for pigments.

Mysore.—Dr. Buchanan makes frequent allusions to the manufacture of iron in different parts of Mysore, and gives detailed accounts of the process.[5] The special interest of these is that they include the

[1] Engineers' Journal, Calcutta, Vol. IV, p. 23.
[2] Madras Jour. of Lit. and Sci., Vol. IV, p. 249.
[3] Mem., G. S. I., Vol. I, pp. 219, 248.
[4] London, 1875, p. 512.
[5] Journey through Mysore, &c., 1807, Vol. I, pp. 29, 30, 32, 170, 175, 179; and Vol. II, p. 16.

earliest descriptions of the manufacture of steel. The localities where there were furnaces were Venkatagiri and Ghettipura, two *coss* from Magadih. Here steel was manufactured and also in several places in the following taluks: Madhu-giri, Chin-Narayan-durga, Hagalawadi, and Devaraya-Durga. In the first two the iron was made from black sand, which the torrents, formed in the rainy season, brought down from the rocks. The furnaces in the Chin-Narayan-durga taluk were on a small scale, the charge of ore being 42½ pounds, from which about 47 per cent. of metal was obtained; work was carried on for only four months, the smelters taking to cultivation during the remainder of the year. The stone ore was smelted in the same way as the iron sand, but the latter, it is said, was alone fit for manufacturing into steel. There were in this vicinity five steel forges, four in the above taluk and one at Devaraya-Durga. The furnace, of which a figure is given by Buchanan, consisted of a horizontal ash-pit and a vertical fire-place, both sunk below the level of the ground. The ash-pit was about three-fourths of a cubit in width and height, and was connected with a refuse-pit, into which the ashes could be drawn. The fire-place was a circular pit, a cubit in diameter, which was connected with the ash-pit, being from the surface of the ground to the bottom 2 cubits in depth. A screen or mud wall, 5 feet high, protected the bellowsman from heat and sparks. The bellows were of the ordinary form, a conical leather sack with a ring at the top, through which the operator passed his arm.

The crucibles, made of unbaked clay, were conical in form and of about one pint capacity. Into each a wedge of iron and three rupees weight of the stem of the *Cassia auriculata*, and two green leaves of a species of *Convolvulus* or *Ipomæa* were put. The mouths of the crucibles were then covered with round caps of unbaked clay, and the junctures well luted. They were then dried near the fire and were ready for the furnace. A row of them was first laid round the sloping mouth of the furnace; within these another row was placed, and the centre of the dome, so formed, was occupied by a single crucible, making fifteen in all. The crucible opposite the bellows was then withdrawn, and its place occupied by an empty one, which could be withdrawn in order to supply fuel below. The furnace being filled with charcoal, and the crucibles covered with the same, the bellows were plied for four hours, after which the operation was completed. When the crucibles were opened the steel was found melted into a button, with a sort of crystalline structure on its surface, which showed that complete fusion had taken place. These buttons weighed about 24 rupees. There were thirteen men to each furnace, a headman to make and fill the crucibles, and four relays of three men each,

one to attend the furnace and two for the bellows. Each furnace manufactured 45 pagodas worth, or 1,800 wedges of iron, into steel. The net profit was stated to be 1,253 fanams, but into the further details as to cost it is not perhaps necessary to enter. The total production of steel in this vicinity was estimated to be 152 cwt., or about £300 worth per annum.

Dr. Buchanan[1] gives details regarding the production at many other localities, but it would be useless to enumerate all these, although they present some differences, especially in the statements made by the operatives as to outturn, prices, &c. The principal sources of the ores were the magnetic sand found in rivers, and the richer portions of the laterite.

The next account of the manufacture of iron and steel in Mysore is by Dr. Heyne,[2] who witnessed the process at a small village among the hills south-west of Chitaldrug, in the Salem district. The nature of the ore is not quite clear from his description, but apparently it was an ochreous limonite, not magnetic. The iron bloom having been manufactured in the usual way, it was refined and cut into thirteen pieces, each weighing 2 pounds, and was sold at the rate of one maund (=27 lbs.) for Rs. 2. These pieces were cut into three, each of which were placed separately in a crucible together with a handful of the dried branches of *tanghedu* (*Cassia auriculata)*, and another of fresh leaves of *vonangady* (*Convolvulus laurifolia*), and closed up with a handful of red mud. The melting then proceeded, as above described by Dr. Buchanan, the operation lasting six hours. The upper surfaces of the resulting buttons of steel were often striated from centre to circumference. Although the metal had lost one-fifth of its weight, no scoria was discernible. The sale price was the equivalent of 10*s*. 8*d*. for 27 pounds. Sometimes the buttons were heated and hammered into bars of 4 or 5 inches long. The stones used in the construction of the furnaces were refractory magnesian schists or potstones called *ballapam* by the natives.

Dr. Heyne also saw steel made at Kakerahally, on the road from Bangalore to Seringapatam. In this case the iron was made from magnetic sand, but he adds that it appeared to be immaterial what kind of iron was used in the manufacture, and that therefore a factory might be established at Madras or any other port. He attributes the fusion of the steel to the exclusion of atmospheric air from the crucible, and the use of fresh vegetables instead of charcoal. From the action of dilute nitric acid, which only left a white mark on the iron, he concluded that it

[1] *L. c.*, Vol. II, pp. 35, 138; and Vol. III, pp. 360, 361, 364, 378, 424, 425, 433

[2] Tracts, 1814, p. 358.

was not steel, as he had at first supposed. Other writers, especially Captain Campbell,[1] have explained the fusibility by the fact that the native iron, when refined, is, in part, really in the condition of steel. According to some authorities the leaves of the *Madar* (*Calatropis gigantea*) were, when obtainable, preferred to those of the *Convolvulus*.

Dr. Heyne quotes a letter from Mr. Stodart, an eminent instrument-maker in England, who stated that the *wootz*, in the condition in which it arrived from India, was not fitted for fine cutlery, owing to its inequality and impurity, but by careful manipulation it was possible to equalise it and bring it to a condition in which it was superior to English cast-steel. The trouble and expense of a second fusion would militate against its introduction into England, but if its manufacture were improved in India, he believed it would be a considerable source of revenue to that country. He had then a good supply of *wootz* by him, and he stated that on the whole the steel of India was the best he had met with. The following information is taken from the Gazetteer of Mysore and Coorg.

Tumkur District.—Iron ore is said to be abundant in the Chikayakanhalli hill, and is obtained in the quarries at Dore Gudda. Yellow ochre, which is obtained there also, is used as a pigment. Magnetic sand is brought down by streams from the rocks in Madgiri and Kostagiri.

Mysore District.—Iron ores, though abundant in the rocky hills throughout this district, are only worked in the Heggaddevankote and Malvilli taluks; in the latter the mines are situated in the Shravana hills, near Tippur. The smelting furnaces are at Hulgur and Husgur; the outturn of iron ranges from 1,500 to 2,000 maunds per annum, of which about half is exported.

Magnetic ore is highly esteemed by the natives for medicinal uses, and drinking out of a cup made of it was one of the prescriptions commended to the late Raja by the native physicians for prolonging his life. It is believed that milk, if boiled in such a cup, will not flow over.

Shimoga, Kadur, and Chitaldrug Districts.—In the Shimoga district iron ores are worked in some parts and magnetic ore occurs at Kodachadri. In Kadur, iron ore is largely obtained and smelted along the hills east of the Baba Budan and those round Ubrani. Iron ores, probably hæmatites, form ranges of hills near Chitaldrug. An attempt has been made, with reference to the province of Mysore, to draw up a table showing the number of mines and furnaces the quantity and value of iron manufactured and exported during the past twenty years, and for this purpose the Annual Administration Reports have been gone

[1] Cal. Jour. Nat. Hist., Vol. III, p. 397; and Jour. As. Soc. Bengal, Vol. XI, p 217.

through, but the details are too incomplete. For several years there is no information, and in some the outturns are apparently in local maunds, in others in British maunds, without being respectively distinguished; while some of the other figures are obviously not to be relied on; but some few facts apparently point to the conclusion that the production of iron in Mysore has diminished by nine-tenths. In 1860-61, the value of 1,200 tons smelted was stated to be Rs. 2,50,000, while in 1878-79 the value of the iron was only Rs. 24,400, or, when manufactured into saleable articles, Rs. 67,644. In 1866-67, 908½ tons of iron were smelted including 336 tons converted into steel. In 1864-65 proposals were set on foot to establish foundries for steel in the Bangalore district, but it is not known whether these came to anything. The decadence does not appear to have been steady; but it is incredible that in the years between 1872 and 1875 there were upwards of 1,400 mines. The royalties in these years on the manufacture exceeded Rs. 8,000 per annum. In some of the returns the weights in maunds! of gold, iron and building stone are lumped together.

Chingleput District: Madras.—So recently as the year 1874, a company was formed, it is believed, in Madras to work the iron ores of the neighbourhood, but how far the intentions of the promoters were carried out is not known, nor is there any information available as to the nature of the ore which it was intended to use; not improbably it was derived from the laterite. In fact the only information before the writer is a letter from Captain Taylor,[1] in which he puts forward his opinions as to the best means of making the Napier foundry a paying concern. He specially insists upon the necessity of producing bar-iron, mentioning that 12,000 tons of Welsh bar, representing a value of 18 lakhs of rupees, are imported annually into Madras. He considers that the Casuarina plantations would be capable of supplying fuel for twenty years, but that before that time Godavari coal, at Rs. 12 to Rs. 15 a ton, or Nilgiri compressed peat, would probably be available. His other remarks refer to the introduction of the hot blast and the best form of furnaces, &c., subjects which need not be further alluded to here.

Kadapah and Karnul Districts.—In these districts, which may most conveniently be treated of together, iron ores occur in great abundance, being found in both of the groups of rocks which bear the same names as the districts. The ore generally worked belongs, however, principally to the Kadapah series; it occurs in layers among the beds or in veins, strings, or nests.[2]

[1] Indian Economist, Vol. VI, p. 131.

[2] C. A. E. Oldham and W. King. Mem., G. S. I., Vol. VIII, p. 277; and Kadapah Manual, p. 26.

A series of iron-smelting villages lie along the eastern side of the Khundair valley from Nundiallumpett northwards near Chintalcheroo (8 miles north of Dhoor). At a small village called Colapetta there were ten furnaces. The ore used was a somewhat silicious hæmatite brought from the hills to the east; the iron was worked up on the spot into agricultural implements. Several furnaces were also in operation at Yerragoontlacotta in the Chittavail (or Rajampett) taluk; here the ore from the Kadapahs is mixed with a laterite ore. In the Rachuti and Cullcudda taluks, near Madicheroo, Nerabyle, and Chintacoonta, iron was manufactured to a small extent, the ore being brought from the hills to the east. In other parts of the district there were also furnaces, and itinerant blacksmiths, carrying with them the implements of their trade, wandered over the district seeking for employment.

In the Karnul district the best ore is found in the Gunnygull range, to the south of Karnul town, the rocks forming which include large veins of pure specular ore in conjunction with lines of fault. A great isolated mass of almost pure specular ore rises out of the base of the northern slopes, but its precise mode of occurrence is concealed. South-east of Ramulkota, on this northern flank, there are altered quartzites, which are highly impregnated with iron, and specular ore occurs there also in great abundance along lines of fault. Scarcity of fuel prevents these valuable ores being largely used.

Ferruginous quartzites crop out all along the western flanks of the Nullamullays from some distance north of Nundeallumpett up to opposite Nundial. The principal smelting villages are Bachapilly, Roodrar, Serinapoor, Kuddamal-culwa, and Galchinpollam. At Roodrar the selling price of the wrought-iron was Rs. 1½ for 9 lbs. weight.

A very admirable paper by Mr. W. P. Wall[1] enters fully into the details of the cost of production of iron at Roodrar and the neighbouring villages, and clearly shows the waste of labour and material involved in the production of the iron, which, however, was sold at the rate of about £20 per ton.

Mr. Wall makes various suggestions as to the methods by which labour might be economised and the production increased, more especially by the employment of water power to produce the blast. He states that in parts of Madras, where English iron cost about £16 per ton, the native-made could command £23 owing to the superior facility with which it could be worked.

Bellary District.—Beyond somewhat vague statements, that iron

[1] Madras Jour. of Lit. and Sci., Vol. XX, new series, p. 299.

ores are abundant in this district, there appears to be but little information available. Some of the ores are said to be manganiferous.

Nellore District.—Mr. R. B. Foote,[1] in his report on the Eastern Coast Region, states that there are two groups of magnetite beds, which he has named the Ongole and the Gundlakumma. They appear to include some rich deposits, but are somewhat variable in quality; they occur interbedded with metamorphic rocks.

In the Nellore Manual[2] there is a somewhat detailed account of the iron manufacture in the various taluks which compose the district. The industry, though holding its own in some places, is in others yielding to competition. Steel does not appear to be manufactured.

Kistna and Godavari Districts.—The manufacture of iron in these districts has attracted notice for many years, and two of Dr. Heyne's Tracts[3] refer to the manufacture of iron at Lutchmiporum and Ramankapetta. Mr. W. T. Blanford[4] has described furnaces which he saw in operation at Polaram and Chitapurn. Mr. King[5] states that the principal sources of iron are the sandstones of Golapilly, Tripati, and Rajahmahendri, especially the latter.

Hyderabad.—Certain tracts in the Hyderabad or Nizam's territory have long been famed for their iron ores and the metal produced from them. The steel mines of Nirmal in the Subah Berar, which are mentioned in the "Ain-i-Akbari,"[6] were not improbably identical with those about to be described. The mode of occurrence of this ore has been described by Malcolmson.[7] The minute grains or scales of iron are diffused in a sandstone-like gneiss or mica schist passing into a hornblende slate. These rocks are excavated with crow-bars and then crushed between stones; if hard, this is done after a preliminary roasting. The ore is then separated from the powdered rock by washing. This was at a village called Dimdurti, but the process of manufacture was the same as that at Kona Samundrum, 12 miles south of the Godavari and 25 from Nirmal, which has been described by Dr. Voysey.[8] The furnace was made of a refractory clay derived from decomposed granite, and the crucibles are made of the same, ground to a powder, together with fragments of old furnaces and broken crucibles kneaded up with rice-chaff and oil. He states that no charcoal

[1] Mem., G. S. I., Vol. XVI, p. 17.
[2] Page 63.
[3] Pages 218 and 225.
[4] Records, G. S. I., Vol. IV, p. 114; and Vol. V, p. 20.
[5] Mem., G. S. I., Vol. XVI, p. 255.
[6] Gladwin's Translations, Vol. II, p. 59.
[7] Transactions, Geological Society, London, new series, Vol. V, p. 546.
[8] Jour. As. Soc. Bengal, Vol. I, p. 245; and Vol. II, p. 402.

was put into the crucible, but some fragments of old glass slag were. A perforation was made in the luted cover. Two kinds of iron, one from Mirtapalli and the other from Kondapur, were used in the manufacture of the steel. The former was made from magnetic sand, and the latter from an ore found in the iron clay (? laterite), 20 miles distant; the proportions used of each were as 3 to 2. This mixture being put into the crucible in small pieces the fire was kept up at a very high heat for 24 hours by means of four bellows and was then allowed to cool down. Cakes of steel of great hardness, and weighing on the average 1½ lbs., were taken from each crucible. They were then covered with clay and annealed in the furnace for 12 to 16 hours, then cooled, and if necessary the annealing was repeated till the requisite degree of malleability had been obtained. The Telinga name for this steel was *wootz* and a *kurs* or cake of it, weighing 110 rupees, was sold on the spot for 8 annas; the daily produce of a furnace was 50 seers, or in value Rs. 37.

A Persian trader from Ispahan was in the habit of going backwards and forwards with the steel; while making his purchases he personally superintended the operations, weighing the proportions of iron, and testing the toughness of the steel himself. He told Dr. Voysey that in Persia the same processes had been tried, but the same quality of steel could not be produced from the ores there. As usual the jaghirdar by his exactions was doing his best to crush out the industry.

As will have been observed there are several remarkable differences in the preparation of this renowned *wootz* from that manufactured elsewhere; especially notable is the degree of heat attained. Dr. Voysey estimated it to be 130° of Wedgewood, and further states the result of different experiments; 25 rupees weight of steel, which had not been submitted to the last operation, was fused in three hours into a button of hard steel, while fragments of different rocks, granite, hornblende-schist, and basalt were fused either into glass or porcelain. The furnaces themselves, which were 4 or 5 feet high and 5 feet in diameter, became semi-vitrified and had to be frequently renewed.

Malcolmson remarks that the ore of this locality must be of exceptional quality, as otherwise it could not have retained its reputation as the best material for Damascus blades, in spite of its remote situation in an unsettled country. He attributes it to a comparatively large proportion of protoxide of iron being present; he failed to find evidence of the existence of titanium.

Dr. Walker[1] briefly describes the ores and manufacture of iron of Hunumkondah in a paper on the productions of that taluk. The ore is

[1] Indian Review, Vol. VI, p. 563.

magnetite, and the iron was purchased by the merchants for Rs. 1½ a maund and was sold at a somewhat higher rate.

Two other papers by Dr. Walker[1] contain further information as to the iron ores of Hyderabad. In the Warungul Circar, titaniferous ore is found abundantly in the nalas; hæmatite is found scattered over the surface near the fort of Warungul, but was not worked. Yellow and red ochre, which were used by the people for ornamenting the walls of their houses, were also obtainable. Extensive smelting of an ore found in the parganas of Kullur and Anantagiri was carried on. An ore found wherever laterite rested on trap was obtained in the Elgundel and Maiduck circars, and was easily mined. There were furnaces for its reduction at Tutapelly and Nizamabad in the former, and Lingumpilly in the latter. He states that it was this iron which was used in the manufacture of the Nirmal steel, but as we have seen above, from Dr. Voysey's account, a mixture of two kinds of iron were used for the purpose.

Vizagapatam District.—Information regarding the mode of occurrence of iron ores in the Jaipur or Jeypur State, and other hilly portions of Vizagapatam, is not very complete. A lode containing a large amount of iron ore on a line of fracture in the rocks of the Karnul series? at Chitra—lat. 19° 4′; long.; 82° 30′, about 12 miles to the south-east of Kotpad, was examined by the writer. It had been extensively mined, a deep trench having been opened along the outcrop for a distance of nearly a mile. The ore formed the matrix of a breccia, and appeared to be a rich brown hæmatite. Most of the other ores which are or have been worked in this region are not improbably derived from laterite. The metal exported to the plains, according to the Vizagapatam Manual,[2] is in the *kachcha* or unrefined state, the retail price being only a rupee a maund; but at Madgole, lat. 18° 2′; long. 82° 30′, *wootz* or steel of fine quality is said to be manufactured. The average annual imports of European iron into Vizagapatam for five years preceding 1869 exceeded 150 tons per annum, so the local supply must be inconsiderable.

The following is a list by Lieutenant J. Vertue,[3] District Engineer of the places nearest the plains where iron ores occur: Dzorapukonda, 20 miles from Narramapatam, quarry; between Dzorapukonda and Lohar-guda, no quarries; Bhittarilotsa, 12 miles from Narrainapatam, a good quarry; Gummidikonda, 15 miles from Narrainapatam, a good quarry; Riga, 10 miles from Narrainapatam, abundance of ore.

[1] Madras Jour. of Lit. and Sci., Vol. XV, p. 222; and Vol. XVI, p. 182.

[2] Page 154.

[3] Madras Jour. of Lit. and Sci., Vol. XXI, p. 271.

Orissa.—The earliest reference to the manufacture of iron in Orissa dates back to 1708. It is by Captain Hamilton,[1] who says that iron was so plentiful at Balasor that anchors were cast there in moulds, but that they were not so good as those made in Europe. It is not stated by whom the process of working in cast-iron was introduced, but there were there at that time factories belonging to the English, Dutch, and French. In all probability this was the first locality in India where the manufacture of iron by the English method was introduced. That the metal was not imported is distinctly implied by Captain Hamilton's remarks.

In 1839 Lieutenant Kittoe[2] reported on the coal and iron of the Talchir and Ungul States. The iron from these States, and those adjoining, used to supply the markets at Cuttack and Berhampur. The metal varied in quality very much, some of it being malleable, while much of it was coarse and brittle. In 1855 Mr. Samuells[3] briefly described the process of iron manufacture practised at Kankerai, in Ungul; the refined iron, which was of good quality, was sold in the Cuttack bazaar for 8 seers per rupee. Analyses of samples of ore forwarded by him were made by Mr. Piddington. The Kankerai ore contained 46·8 per cent. of iron, and another from Pal-lahara contained 47 per cent. with a small quantity of manganese.

In 1879 Dr. Oldham published a memorandum on the coal and iron of Orissa as an introduction to the report on the Talchir coal-field by Messrs. Blanford and Theobald.[4] A detailed account of the native process is given, which resembles in its general features that in practice all over the country, of which a typical case will be described under the head of Palamow. The resemblance is pointed out in the details of the process to that which was in practice formerly in England, as described by Dr. Plot in his Natural History of Staffordshire.

The ores used in Talchir vary. Sometimes ironstone shales of the Barakar or coal-measure group are employed; sometimes concretionary masses found in the detritus of the upper groups; nodules of laterite are also sometimes used.

Altogether the system of manufacture of iron in the Orissa Tributary States is on a very rude and petty scale. The furnaces are exceptionally small, and the charcoal is prepared by cutting down a tree, setting fire to it, and after it is partially consumed quenching the flames and simply knocking off the charcoal from the half-burnt log. The slags from the furnaces generally retain at least 40 per cent. of iron.

[1] A new Account of the East Indies, Vol. I, p. 393.
[2] Jour. As. Soc. Bengal, Vol. VIII, p. 144.
[3] *Idem.*, p. 250.
[4] Mem., G. S. I., Vol. I, pp. 11 and 85.

There does not appear to be any good ground for supposing that Orissa offers any advantages over many other localities for the introduction of an improved system of iron manufacture.

Birbhum District.—The history of the attempts which have been made to establish iron-mining on the European system in the district of Birbhum is a long one, dating back so far as the year 1777. It fully supports the truth of the old adage that history repeats itself. The same sanguine hopes, the same attempts to carry on work in spite of discouraging circumstances, the same failures and the final loss of expended capital, are recorded in the accounts of each attempt. In so far as reports by experts are concerned there are a good number of them.

The first application to work the mines of Birbhum by an improved system was made in 1774 by a native, Indarnarain Surma, who offered terms to the Government through the Bardwan Council, which it was not likely he would ever have been able to fulfil, as they involved, after the fourth year of occupation, the payment of a rent of Rs. 5,000 per annum.[1] Though the offer was accepted the lease was never taken up. In 1777, Messrs. Motte and Farquhar memorialised Government to be allowed the exclusive privilege of manufacturing iron in the Honourable Company's possessions in the country west of the meridian of Bardwan, and of selling the produce free of duty. This was without prejudice to the rights of Messrs. Summer and Heatly, who had mining privileges in certain districts of Birbhum and Pachete. They claimed to be exempt from all interference by the members of the Bardwan Council, and any of the Company's officers resident in the provinces included in the abovementioned limits; all matters of dispute to be referred to the Governor's Council, as the local officials, being traders in these districts, might be interested judges. The place first selected by them for the furnaces was strangely enough situated in Jharia in Pachete, but the *loha mehals* of Birbhum were to be made over to them on the existing terms and conditions. On their part they contracted to cast shot and shells, and to supply them at Fort William, at four-fifths of the average cost of the same when landed from Europe. They further contracted to pay to the Company one-twentieth of the profits of the lead mine (at Hisatu or Sidpa) in Ramgarh, which they also proposed to work (see page 291).

In the following year permission was granted to Mr. Farquhar to enter into possession. He then begged an alteration in the terms, having in the meantime discovered that the ores of Birbhum were better suited to his purpose than those of Jharia. This was granted, but a

[1] Jour. As. Soc. Bengal, Vol. XII, p. 546.

series of troubles awaited him from the opposition of the jaghirdars and Raja. In 1779, after further correspondence, an advance of Rs. 15,000 was made by Government to Mr. Farquhar, in order to enable him to complete his furnaces, &c., and he carried on from that time to 1789, with what result, as regards the manufacture of iron, is not known; but the records are full of accounts of disputes and contests with the natives, who actually claimed that the revenue from the *loha mehals* belonged to them, though Government had received it before Farquhar obtained the lease. In 1789 he relinquished the speculation and was appointed to the gunpowder manufactory at Phulta, but he retained the lease of the *loha mehals* till 1795, after which they lapsed to the zemindar, who disposed of parts of the estate, and the new proprietors commenced to levy dues on the iron mines within their lots, and as a matter of course litigation ensued. Finally the Court (Sudder Dewanny) issued rules which established and defined the rights of the holder of the *loha mehals*, who had purchased them as a separate lot at the ultimate sale of the zemindari. It would seem, therefore, that the Government had allowed the mining rights, their claim to which they had distinctly asserted when leasing the mines to Farquhar, to slip through their fingers.

It is stated that Birbhum hook iron, during the period of Farquhar's labours, was sold in Calcutta at Rs. 5 per maund, Balasor at Rs. 6-8, and English at from Rs. 10 to Rs. 11. In all probability this iron was produced by the direct native process, not by European methods. The above is taken from one of a series of "contributions towards a History of the Development of the Mineral Resources of India by S. G. T. Heatley."[1]

In 1845, Mr. Welby Jackson[2] communicated a short account of the Birbhum iron works as they were then carried on by natives. There were about thirty furnaces, which he says produced, at a cost of Rs. 17, about 25 maunds of iron at each smelting, which lasted for four days and nights. He alludes to the work as gradually destroying all the fuel in the vicinity. The farmer of the *loha mehals* claimed one rupee for each smelting and 6 pice on each maund of refined iron. Mr. Jackson enquired into the monopoly which struck him as curious, and was told that it came about as has been above described. He left the district before he had fully enquired into the matter, but he states that he doubted the right claimed and could not conceive how it had originated. He was not apparently aware of the full facts of the case, namely, that a predecessor of his had sold on behalf of the Raja's estate what was really Government property.

[1] Jour. As. Soc. Bengal, Vol. XII, 1843, p. 542.

[2] *Op. cit.*, Vol. XIV, p. 754.

The next account by Mr. H. Torrens appeared in 1850. He describes the iron-smelters of the hills as an itinerant race using small furnaces; they belonged, he says, to the Santhal tribe (they were really a local tribe of Munda Kols). The price of the iron on the spot was Rs. 3 a maund.

Two years later Dr. Oldham reported on the iron ores of Birbhum and the Damuda valley. His attention had been especially directed by the Court of Directors to the question of iron manufacture in connection with the introduction of railways into India. In this paper there is the first description of the nature and mode of occurrence of the ore, which is described as consisting of partly earthy and partly magnetic oxides of iron, which occur disseminated among and spreading in an entangled manner through soapy trappean claystone, its origin being due to infiltration into cracks and joints. The bed or layer impregnated was stated to be 5 feet thick. Altogether Dr. Oldham's opinion as to the available amount of ore was that the supply was not so great as subsequent investigations have shown it to be. Native furnaces, on the large scale which seems to distinguish those of Birbhum from any found elsewhere in India, were in operation at four centres, namely, Ballia, Narainpur, Deocha, Dumra, and Goanpur. At Deocha there were thirty furnaces for the reduction of ore; these were worked by Mahomedans, the refiners being Hindus. The estimated average outturn from each furnace in the year was 34 tons of iron, and as there were believed to be in all seventy furnaces, the total outturn of *kachcha* iron was estimated at 2,380 tons in the year. In these furnaces the *kachcha* iron, unlike that produced in other parts of India, formed at the bottom of the furnace in a molten condition, and resembled good pig-iron. The refining was really a sort of puddling process, which induced a pasty condition admitting of the iron being drawn out and hammered until it became thoroughly malleable.[1] Ten maunds of the *kachcha* iron were said to yield seven maunds and ten seers of the *pakka*, from which the outturn of refined iron was deduced to be, in round numbers, 1,700 tons, at a cost of £4-4-0 per ton. To prepare this in marketable shape as bars, &c., would require, according to Dr. Oldham's estimate, an expenditure of 50 per cent. additional, the final result being that at £6-6-0 it could not compete with English iron, at the prices then prevailing in Calcutta, though, being a charcoal iron, its softness made it better suited for some purposes than English iron. In view of the daily increasing difficulty about fuel, Dr. Oldham finally concluded that the absence of economical fuel and the scanty supply of

[1] *Vide* Engineers' Journal, Calcutta, Vol. III, p. 112.

ore determined the inapplicability of any extended series of operations for smelting and manufacturing iron in the district of Birbhum.

In a paper read before the Asiatic Society in 1854,[1] Dr. Oldham describes the iron manufacture by the Kols of the Rajmahal hills. The principal sources of the ore were the ferruginous sandstones which overlie the trap. Sometimes, however, they used a lateritic ore. Allusion is made to an old report that Sikrigalli was a suitable place for the manufacture of iron, but it is stated that there was no ground for supposing that there existed in that vicinity conditions favourable for such a manufacture. This report appears to have been originated by Mr. Jones, who in 1829 stated, apparently on hearsay, that large iron mines had been worked at Sikrigalli and Pirpainti. It would not perhaps be safe to say that no iron exists in these neighbourhoods, but it is very unlikely that large deposits exist, and it is doubtful whether there were ever any furnaces near either.

Somewhere about the year 1855, Messrs. Mackey and Co., of Calcutta, started the Birbhum Iron Works Company, and fixed upon Mahomed Bazaar as the site for their factories and furnaces. In 1856 their property was reported on by Mr. James Barratt,[2] and he speaks in glowing terms of its value, especially as regards the quantity, quality, and variety of iron ores to be found. The coal at Panchbyni, he admits, is unfit for smelting, but thinks better qualities may be found below. A bed of limestone at Sitakabr, 2 miles south-west of Dumka, is mentioned, but this does not appear to have ever been exploited.

In 1858, Mr. Sowerby,[3] in his report on the Kumaun mines, made some depreciatory remarks regarding Mr. Mackey's iron works, which called forth a rejoinder from that gentleman and his manager, Mr. Casperz.[4] They stated that the ore they were using contained 46·5 per cent. of iron, was readily fusible, and that they were turning out two tons of pig a day, which had been reported on in England to be equal to No. 1 gray pig. It was stated that one ton of iron could be delivered in Calcutta at Rs. 37, which would enable it to compete favourably with English metal; but that as a matter of fact better prices could be obtained nearer at hand. In spite of all this, operations from one cause or another ceased from time to time.

In 1860, Mr. W. T. Blanford reported at considerable length on the condition of Messrs. Mackey's iron works, and the best method of improving the outturn. His deputation was in response to a special

[1] Jour. As. Soc. Bengal, Vol. XXIII, p 279.

[2] Report to Messrs. Mackey and Co., dated Birbhum Iron Works, December 1856.

[3] Selections from Records, Government of India, No. XXVI, p. 56.

[4] Engineers' Journal, Calcutta, Vol. III, pp. 58, 98, 106, 112.

application made by Mr. Mackey for an inspection by a Government officer in anticipation of an attempt to increase the capital with a view to the enlargement of the works. Mr. Blanford gives the following conclusions in recapitulation of his report:—

(1) That the manufacture of iron is at present carried on at a loss;

(2) That by the employment of additional capital, and increasing the production, the cost may be very far diminished, and the iron be produced at the works for about Rs. 37½ and supplied in Calcutta for Rs. 44½ per ton;

(3) That the price of English iron in Calcutta for the last ten years has averaged considerably more than the above sum, *viz.*, Rs. 51-6, and that for the last six years it has averaged Rs. 57-14 per ton, which prices exceed the estimate of the cost of Birbhum iron in the proportion of 16 and 20 per cent. respectively;

(4) That the iron produced is of quality superior to ordinary English pig-iron, that it is generally gray, and that it appears to be well suited for castings requiring strength and toughness;

(5) That the supplies of ore, flux, coal, and charcoal are sufficient for works of moderate size, provided careful supervision is exercised over the cutting and burning of the wood for charcoal;

(6) That the supply of charcoal, and perhaps also of flux, is not sufficient for very large works;

(7) That economy will be consulted by erecting different furnaces at different places in the district, the neighbourhood of Panchbaini and Ganpur, for instance, being apparently adapted for the production of iron at a lower cost than can be effected at Mahomed Bazaar;

(8) That the district is not so well qualified for the manufacture of iron by means of coal, as is the neighbourhood of Raniganj, and that works established at Birbhum would have to compete at great disadvantage with any established in the Damuda field.

The ore in Birbhum occurs in beds towards the base of the laterite. These are possibly not constant in thickness for long distances, but on this point, since they are only known from the sections made in shallow pits, there is no definite information. It has been fairly established, however, that ore is abundant, and that it contains a high percentage of iron, occasionally nearly 60 per cent. and averaging over 40.

In the year 1875 Mr. Hughes reported on the prospect of iron manufacture in Birbhum, and shortly afterwards Messrs. Burn and Company commenced operations; but after some months' trial it was found that the prospect of enlarging the works did not promise to be a profitable speculation, and thus the last of the many attempts to manufacture iron which have been made in this area, ceased.

There can be little doubt that the fuel is wholly insufficient. It is now even less abundant than it was when Mr. Blanford wrote. The native rights, real or assumed, would be a constant source of annoyance and trouble, and though the ores are somewhat richer there is no comparison between the advantages of this area and those of the Raniganj field. Further information on the subject will be found in the work noted below.[1]

Monghyr District.—Iron ores occur both in the laterite and in thin bands in the schists of the Kharakpur hills, and the making of iron is still practised to a small extent. The richest source of iron ore is said to be situated near Bhimband. In several places ochreous ores are employed as pigments.

It may be of interest to state here the circumstances connected with the discovery of a mass of iron in this region, which was forwarded to the Asiatic Society at Mr. Piddington's request by Captain Sherwill. It was stated to have been originally found embedded in the soil on the top of the Kharakpur hills, and it had been exhumed and worshipped for many years by the hillmen. Its weight was 156½ pounds. Mr. Piddington[2] published two papers on the subject in the Journal of the Society, in which he came to the conclusion that it was a veritable meteoric iron, having found, he believed, traces in it of nickel, cobalt, and chromium. In 1862 Prof. Haidinger[3] published a short paper on a sample of this iron, in which he shows that, according to an analysis by Herr Karl Ritter von Hauer, the mass consisted of 98 per cent. of iron with silica and carbon, but that there were no traces of the above-mentioned metals, the conclusion from which, and from the physical characters, was that it was not of meteoric origin.

The original is now in the Museum, and on a comparison with a bloom from a native furnace in Hazaribagh, it is seen to be of absolutely identical character, and not a vestige of doubt can remain that it was made in an ordinary native furnace, the hearth being accidentally somewhat larger than usual, as was evidently the case from the inequilateral shape of the mass. A projecting circular portion on the upper surface exactly

[1] Mem., G. S. I., Vol. XIII, Part 2, p. 87.

[2] Jour. As. Soc. Bengal, Vol, XVII, p. 538; and XVIII, p. 171.

[3] Sitzungsb. der Akademie, Wien. XLV, p. 672.

corresponds with what is seen on ordinary blooms, which show the shape of the base of the cylindrical shaft of the furnace before it opens into the hearth. It is possible that owing to the accidental size of this bloom it was unmanageable, or was perhaps thought to be uncanny, and it was therefore made an object of worship.[1] In fact the only thing remarkable about it is that it is purer and less mixed up with extraneous matter than is commonly the case.

An iron mine in the Kharakpur hills, which was visited by the writer, had been deserted in consequence, as the natives say, of some of the ore, when smelted, changing into milk and blood, which was followed by deaths in the families of the persons engaged. It is possible that the ore may have contained lead or tin, and the resulting white metal may have been thought by the superstitious smelters to be the harbinger of disaster.

Raniganj field.—The literature referring to the iron deposits of this area, though considerable, is less voluminous than that on the iron ores of some other parts of India. It dates back to a period fifty years ago, since which time, at intervals, propositions have been made to start iron works, and at one time the Bengal Coal Company took some preliminary steps with reference to the manufacture of iron on a large scale, but although some of the machinery was ordered nothing further was done, as the company concluded that it would be safer for them to confine their operations to coal-mining.

It was not until the year 1874 that the matter was regularly taken up and a company formed under the title "Bengal Iron Company." In the year 1879 this company ceased operations. The causes which brought about this disaster were principally due to the fatal and initial error of starting with insufficient capital, which only amounted to £100,000. An altogether unexpected and heavy charge for the land which was taken up made a serious inroad into this sum. Hopes were raised that Government aid would be forthcoming to enable the company to obtain additional capital from the public upon moderate terms, but unfortunately the security asked for was not granted. Money was raised on debentures, but at a high rate of interest, and although the Government so far aided the company that it gave large orders for castings, the work had to be stopped, and a large number of people were thrown out of employment, the shareholders lost their money, and the coal trade suffered from the loss of a good customer.

Material exists for giving a very complete account of what was accomplished by the company, but as much of it consists of details

[1] *Vide* Proc. As. Soc. Bengal, August 1880.

hardly suitable to these pages, and as they are, moreover, accessible in original to those who may be specially interested, the following brief account [1] of the materials which are available, and the character of the iron which was turned out, will probably be sufficient for present purposes. Should a new company ever be formed, it will have the immense advantage of availing of the experience acquired during this first costly experiment. In matters of detail as to the form of the furnace and the economy of heat, preliminary calcination of ore and flux, &c., &c., there was much improvement possible, and that iron would have been turned out ultimately at a cheaper rate and better quality, had the company survived, it is impossible not to believe.

Ores.—The iron ores of the Raniganj field all occur in the ironstone shale group which intervenes between the two coal-bearing groups, Raniganj and Barakar, of the Damuda series.[2] These ironstone shales have a wide extent, being traceable by their outcrops at the surface for a distance of several miles. The estimated thickness of the group is 1,400 feet. The ore does not occur throughout, being most abundant towards the top and bottom, where it occurs in bands, lenticular masses, and strings of nodules. It is a clay iron ore somewhat altered at the surface. In places, too, a regular black band has been met with. As a general rule, it is easily obtained at or near the surface, and for a long time regular mining would not be necessary. In the case of the Bengal Iron Company, the ore which was used was collected on the company's property, and cost when laid down at the furnaces only eight annas a ton, or a very much less sum than previous estimates had allowed for it.

Analyses by Messrs. E. Riley and H. Foster [3] respectively gave the following results of ores used by the company :—

Iron as peroxide	68·72	65·54
Manganese as protoxide	2·67	2·78
Lime and magnesia	2·10	tr.
Alumina	5·14	8·82
Silica	10·17	12·93
Phosphoric acid	·44	·09
Sulphur	tr.	tr.
Water	11·13	10·10
Total	100·37	100·26

[1] Derived from official papers and information kindly supplied by the company's agents.

[2] W. T. Blanford. Mem., G. S. I., Vol. III, p. 191.

[3] See Mr. Ness' Report, *Gazette of India*, 1879.

An analysis by Mr. Pedler of an ore which was also used gave the following result, showing that the constituents vary to an extent which might cause serious trouble in the furnaces were a chemist not at hand to constantly check the proportions of the charges from time to time:—

Silica and silicates, insoluble in acids	25·41
Iron as protoxide Fe O	1·26
Iron as peroxide Fe_2O_3	43·09
Aluminum oxide	12·53
Calcium carbonate	6·72
Magnesium carbonate	1·88
Phosphorous protoxide P_2O_5	1·25
Water driven off at 120°	3·96
Combined water, carbonic acid combined with iron oxide and alkalies	3·90
Total	100·00

Mr. Bauerman gives the following as the result of the assays of ores which were obtained by him in this region:—

	Iron.	Phosphorus.	Insoluble.
Barakar carbonate	29·5	0·398	14·57
Badul "	24·24	1·004	28·73
Grand Trunk Road near Barakar	49·63	0·420	13·50
Ditto ditto	34·84	0·363	15·85
Brown ore, Barakar railway	38·63	1·960	16·63
Ditto ditto	38·09	1·830	17·09

For other analyses reference should be made to two papers on the subject by Mr. Hughes.[1]

Flux.—Although the existence of two principal and several minor sources of rock limestone had been known for nearly ten years[2] before the Bengal Iron Company came into existence, and a map indicating their positions had been supplied by the Geological Survey, still attention was at first rather directed to the employment of kankar or *gutin*, or, in default of it, to the limestone of Rotas. The irregularity in composition of the former and the high price of the latter (when delivered at the works), showed that they were both unsuited to the requirements, and at length attention was directed to the above-mentioned sources. One of these was a bed of dense gray limestone, in places 11 to 12 feet thick, which occurs

[1] Records, G. S. I., Vol. VII, pp. 20, 122.
[2] *Op. cit.*, Vol. X, p. 152.

associated with the top of the Raniganj or the base of the Pachete rocks at the north-western base of the hill bearing the same name. The other locality was situated a few miles to the south-west of this, in the neighbourhood of Hansapathar, in crystalline rocks. One other locality where limestone occurs, though the extent of the deposit is not known, is situated on the line of fault bounding the coal-field at Jamuan, 6 miles to the south[1] of Raniganj and 9 miles to south-east of Assensole. As it occurs in a fissure, it is possible that it may not be extensive. A dolomitic limestone, possibly of greater extent, is found near Ramlallpur, about 7 miles south of Raniganj, but this is less likely to afford a suitable flux. The two first-mentioned sources, since they have been opened up, it is now known, would afford inexhaustible supplies of flux, though not of the best qualities.

The following analyses by Mr. Pedler indicate high percentages of impurities :—

	Pachete.	Hansapathar.
Insoluble silica and silicates	11·99	31·31
Calcium carbonate	71·45	67·30
Magnesium carbonate	8·21	0·57
Aluminum oxide	5·65	0·73
Iron oxide	2·65	
Alkalies	·05	·09
Total	100·00	100·00

Mr. Mallet[1] has given a very full account of the mode of occurrence of these two limestones. At the time he examined them they had been opened up to some extent, and there was therefore greater facility for examination than when they were first discovered. His analyses are as follows :—

	Pachete.		Hansapathar
	Upper.	Lower.	
Calcium carbonate	45·05	63·40	83·43
Magnesium carbonate	11·53	11·41	·78
Ferrous „	3·64	4·15	·68
Ferric oxide	·28	·62	...
Phosphoric acid	·07	·12	·02
Insoluble	39·28	19·28	16·18
Total	99·85	101·98	101·09

[1] Records, G. S. I., Vol. X, p. 151.

The upper band at Pachete was not used. The Hansapathar rock is practically inexhaustible, the outcrop indicates a thickness of 150 feet, and it is traceable for 2 miles.

The cost of these limestones, when delivered at the works, amounted to Rs. 4 per ton, which included charges for 10 miles carting, crossing the Damuda in boats, quarrying, and royalty. This was a high price as compared with that of kankar, which could have been delivered, it was estimated, at a cost of Rs. 2 per ton.

Fuel.—The principal fuel used was coke, which was made from the coal of the Karharbari mines, in the field of the same name, or from the coal obtained in the mines at Sanktoria, Pura, and Belrui, all of which are in the Raniganj field, and within a radius of 3 miles of the iron works. That from Pura, at a cost of Rs. 10, delivered at the works, was chiefly used. An analysis of it by Mr. Pedler gave the following result :—

Fixed carbon	84·36
Sulphur	·24
Ash	14·84
Water	·56
	100·00

A daily outturn of twenty tons from one of the furnaces required a charge of the above materials in the following proportions :—

Iron ore	36·52 tons.
Coke	27·6 ,,
Limestone	23· ,,

The yield of pig, therefore, was nearly 23 per cent.

The pig iron produced left the furnace in a highly fluid condition, the consequence of which was that it made sharp castings, but this indicated the presence of a large percentage of phosphorous, and on analysis it was found that an amount was present which a few years ago would have operated very prejudicially if the pig was intended for conversion into wrought iron or steel. By the application of the new dephosphorising process, patented by Messrs. Thomas and Gilchrist, this, though it is believed that in England it causes an extra expense of 15 shillings per ton, has been found capable of producing, from phosphoretic ores, when treated in the Bessemer converters, a quality of steel equal to that obtained from ores which are comparatively free from phosphorus.

Several analyses of the pig, which were made, gave the followin results :—

	Tatlock.	Pedler.	Mallet.
Iron	90·16	90·580	91·91
Carbon combined	·36	·138	2·71
„ as graphite	2·10	2·700	
Manganese	·69	·968	
Silicon	4·32	4·139	3·13
Sulphur	·07	·116	·30
Phosphorus	2·30	1·359	1·95
Total	100·00	100·000	100·00

The average percentage of phosphorus derived from these would be 1·869; the precise source of this large proportion is somewhat obscure, but probably the flux as well as the ore contributed to it.

As a means of reducing this, and also of generally improving the character of the steel, the application of the dephosphorising process in Bessemer converters would doubtless prove to be completely efficient.

From its commencement to the time of its stoppage the Bengal Iron Company made 12,700 tons of pig iron. The daily outturn was 20 tons. At first the cost amounted to Rs. 80 per ton, but this was subsequently reduced to Rs. 40, and had both furnaces been in operation together it was estimated that the cost would have been further reduced to Rs. 33.

Mr. Bauerman's estimate of the probable cost of iron made in the Raniganj field was £5 a ton. The quality of the metal, taking the average of the ores, would, he considered, resemble that of Cleveland or Northamptonshire, and such as might be used for common casting and for rail manufacture, but not for making high-class malleable iron. He considered therefore, that, except when prices were exceptionally high in England, iron could not be made profitably at Raniganj.

The applicability of Sieman's process and others for direct conversion of the iron, without contact with the fuel, has been discussed by several of the writers on these ores.

Manbhum District.—Although a portion of the Raniganj coal-field is situated within the limits of the Manbhum district, it has been more convenient to treat of the iron ores of that field collectively, as, though the localities were all included in Bardwan, further reference to them, therefore, need not be made here.

In the Jharia coal-field both Mr. D. Smith and Mr. Hughes[1] have reported unfavourably as regards the quality of the iron in the ironstone

[1] Mem., G. S. I., Vol. V, p. 332.

shale group. According to the latter, they are so silicious that the native smelters can do little with them. The ore they chiefly use consists of ferruginous concretions from beds of shale and sandstone of various ages.

Throughout Manbhum, in those parts where metamorphic rocks prevail, greater or less quantities of magnetic iron sand are to be found in the beds of rivers, and scattered generally throughout the superficial deposits; occasionally titaniferous ore is associated with this magnetic sand, and this may perhaps account for the excellent quality of some of the iron which is produced. It is exceptional, however, to find this sand used, as its collection is troublesome, and it is generally found necessary to grind it to a fine powder before smelting it. No very considerable deposits of magnetic ore have been yet found in the metamorphic rocks; one of the most important as regards position is found in a small hill near Teludhi, close to Baharinath. It has been supposed that a large amount of ore could be obtained there to mix with the ironstone ore of the Raniganj field, but this is doubtful judging by the appearance which is presented at the outcrop.

In the sub-metamorphic rocks, far to the south, there are some apparently bedded magnetites seen in the section in the Kasai river. These at first sight, on the weathered surface, so resemble the interbedded or meta-diorites that their true character as massive bright ore is not recognised until they are broken. These would probably yield a large supply of ore, but they are rather inaccessible.

At various places along the line of disturbed junction between the metamorphic and sub-metamorphic rocks of Manbhum, which runs nearly due east and west across the district, there are veins or lodes of red and brown hæmatites; the latter sometimes in great abundance. Doubtless this deposit has resulted from infiltration on the line of fracture. In many places replacement has been in operation, and the iron is now represented by quartz which is pseudomorphic after micaceous iron.

The principal of these lodes are indicated on the recently published map of this district,[1] and the positions of other deposits further south are also shown; some of the latter occur in close relationship with the Dalma trap. These ores would be of great value if situated nearer to the Raniganj coal-field, but their position would involve long and difficult carriage.

Native furnaces of the form which will be described in the account of Lohardaga, and which is represented by Plate V, are in operation

[1] Mem., G. S. I., Vol. XVIII, Pt. II.

throughout the area, and the vast accumulations of slag testify to the antiquity, rather perhaps than to the magnitude, of the manufacture.

Singbhum District.—Although iron ores are perhaps not so abundant in this district as they are in Manbhum, there are still several localities where supplies of good ores could be obtained[1] in any quantity, and without much difficulty.

A large proportion of the ore used in native furnaces in some parts of the district is derived from ferruginous schists, but from these sources no regular or considerable supply could be obtained. As in Manbhum, very pure hæmatites occur in association with the trap. In the eastern parts of the district laterite ores, as is also the case in Manbhum, though not mentioned above, are sometimes used by the iron-workers.

By far the most promising source of iron ore in Singbhum is to be found in a number of lodes or veins which occur in the neighbourhood and to the west of the town of Chaibassa. Some of them might prove rather refractory, still the fact that others are used by the natives is encouraging, but what more than anything else gives them an especial value is that many of them are manganiferous to some extent, and it is just possible that they might prove suitable for the manufacture of a substitute for *spiegeleisen*, and might be made available for iron works in the Raniganj field if the line of railway to the Central Provinces should pass near them.

Hazaribagh District.—An altogether imaginary, exceptional richness and abundance, which has been attributed to the iron ores of Hazaribagh, as contrasted with those of the adjoining districts, has been the cause of various schemes being promulgated for the establishment of iron works there.

It is perfectly true that rich iron ores, fuel, and flux are all found in the district, and it is further the case that a large amount of iron is annually produced from native furnaces; but in reference to no one of these items can Hazaribagh compare favourably with Raniganj or Palamow, and as regards accessibility the advantages possessed by both, the former especially, would go far to make up any inferiority in other respects if it had any existence, which, however, it has not.

In the area occupied by the crystalline or metamorphic rocks there are numerous localities where the existence of magnetite in abundance had been reported; these were all examined by Mr. H. Bauerman and the writer, and in not one single case was there any evidence of an abundance of ore, but rather the contrary; while in many cases the supposed magnetite proved in reality to be massive garnet, or the calderite

[1] Mem., G. S. I., Vol. XVIII, p. 146.

of Piddington; this might perhaps be capable of affording a flux, but to be regarded as an ore of iron it has no claim.

In the valley of the Damuda the supplies of ore used in native furnaces are chiefly drawn from the weathered outcrops of the ironstone group of the Damuda series which is represented in both the Bokaro and Karanpura fields. The native furnaces are numerous.

Lohardaga District.—Except in the sub-division of Palamow, and the Toree pargana, there are no coal-fields in this district. Putting it out of consideration, therefore, for a moment, the sources of iron ore in Lohardaga are all included in the two series of metamorphosed rocks and in the laterite. So far as is known at present, these sources are nowhere of exceptional richness, nor does the indigenous manufacture of iron offer any special points of interest. The furnaces are to be found only at wide intervals, and the amount of iron produced is probably not more than sufficient, if even it is that, to supply the local consumption.

In Palamow,[1] however, there is a remarkable abundance of ores, and the other materials required in the manufacture of iron, while its position and the early prospect of its being, by means of steam-tram and canal, brought into communication with the East Indian Railway place it in an altogether different category from all other parts of Chutia Nagpur as a site for an iron factory. Such being the case it is deserving of some special and detailed description here.

Palamow Sub-division.—The iron ores of Palamow admit of a triple classification, which is based both on their mode of occurrence and their chemical composition. So arranged they stand as follows:—

Magnetite ...	(*a.*) Pure magnetic ore (*b.*) More or less decomposed and altered.	This occurs either in bands or veins, in hornblendic rocks, or as disseminated crystals in granite.	Crystalline and metamorphic rocks.
Siderite and Hæmatite.	(*a.*) Carbonate or black band (siderite). (*b.*) Limonite or brown hæmatite. (*c.*) Red hæmatite.	(*a.*) Bedded shales. (*b.*) Concretionary masses in sandstones.	Coal-measures, Barakar group.
Red and Brown Hæmatite ...	Strong bands of one or other of these ores occur in the laterite which caps the plateaus above 3,000 feet in elevation.	......	Laterite.

[1] Mem., G. S. I., Vol. XV, part I, p. 112.

For some years before 1878,[1] when this area was specially examined with reference to the iron ores, attention had been drawn to it as offering a suitable field for manufacturing iron, and although the data upon which this opinion had been founded were somewhat incorrect, the result of the examination has been to show that the materials requisite in iron manufacture are all to be had in abundance within the limits of the sub-division. In the earlier notices of these ores the accounts of the abundant supplies were founded on a combination of the richness of certain magnetic ores with the abundance of laterite ores. Magnetic ores do occur at more than a dozen localities, but that they are abundant at any of these may be doubtful. They occur sometimes more or less massive in nests or bands in hornblendic rocks, and occasionally in crystals, which are thinly disseminated through granite veins. The principal form in which this last is used by the native Agarias is when it is obtained by sifting and washing from the decomposed detritus from the granite veins. The small, partially decomposed crystals are ground between stones to a fine powder before being smelted. In one case an altered massive magnetite near Kurchi is used to some extent, but the pure ore is not known to be used in any case by the natives, who declare that it is not suited for their purposes.

At none of the localities which have been examined is there distinct evidence of the existence of a practically inexhaustible supply, nor does the mode of occurrence in veins, with steep underlie, favour the view that a simple system of mining would be applicable. Limited supplies of this ore for special purposes could no doubt be obtained at little cost. Laterite ores of excellent quality, as will be seen from the analysis quoted below, and in great abundance, occur, and are worked by the natives; but their situation at the top of lofty plateaus precludes the possibility of their being made available at a reasonable cost at any accessible locality.

As neither of these sources of ore afford a prospect of being applicable to the requirements of a large factory in a suitable position, it is fortunate that there is still another source of ore which affords more favourable conditions. This ore is found occurring in beds in the Barakar rocks, at the eastern end of the Aurunga field, near Rajbar. It occurs in a well-defined zone of ferruginous shales, about 200 feet thick, of which perhaps 10 per cent. consists of what may be called iron ore. A fair sample of the richest band contained 49·2 per cent. of metallic iron, and as the zone containing it extends for 2 or 3 miles, no doubt can exist as to its abundance,[1] and since the dip is only 5° it might be easily worked. There is, however, a more abundant source of ore in a detached

[1] Mem., G. S. I., Vol. XV, part 1, p. 112.

area of Barakar rocks to the north of Balunagar,[1] where the iron-stones occur in abundance over an area of about 4 square miles. At first sight it might be thought that these, or some of them, were to be identified with the true ironstone group, but they are overlaid by sandstones of Barakar character. As in the case in the main field, the good ore, visible in the sections, is about 10 per cent. of the whole thickness. The best bands generally have a lenticular shape and die out, but are soon replaced by others, so that the average proportion is kept up. These ores are largely worked by the natives, and in several places at the outcrops there are shallow pits, from which they are extracted; one sample of the ordinary ore yielded 45·3 per cent. of metallic iron, and one of black band, 39·4 per cent. As full details of these ores are given in the volume quoted, it will be unnecessary to say more on the subject. A truly remarkable supply of most excellent crystalline limestone occurs in the metamorphic rocks close by. The zone of often nearly vertical rocks in which it occurs is, at the surface, upwards of a mile wide, and the longitudinal extension is known to be 4 miles long and may be much more. A sample assayed by Mr. Mallet contained:—

Carbonate of lime	91·9
" " magnesia	·2
Oxide of iron and alumina	·7
Insoluble	7·2
	100·0

It would therefore yield a very superior flux.

The question of fuel is by no means yet settled. There are in this small outlier several coal seams, which, though they do not present a promising appearance at the outcrop, may contain good fuel, and the same remark applies to the main Aurunga field. If neither of these should prove to contain suitable fuel, then that of the Daltonganj field might be used, but then the cost of carriage has to be considered. The distance of the iron and limestone from the Daltonganj field, which by means of a steam-tram and the already existing canals will shortly be put in communication with the East Indian line, is 50 miles, so that, under existing circumstances, it seems scarcely likely that it would pay to work these deposits. Were good coal even found on the spot, the iron, until better means of communication were opened up, would have to be carted over difficult roads for a distance of 50 miles.

The following table gives the results of the examination of the iron ores of Palamow in the field and in the laboratory.

[1] Mem., G. S. I., Vol. XV, p. 79.

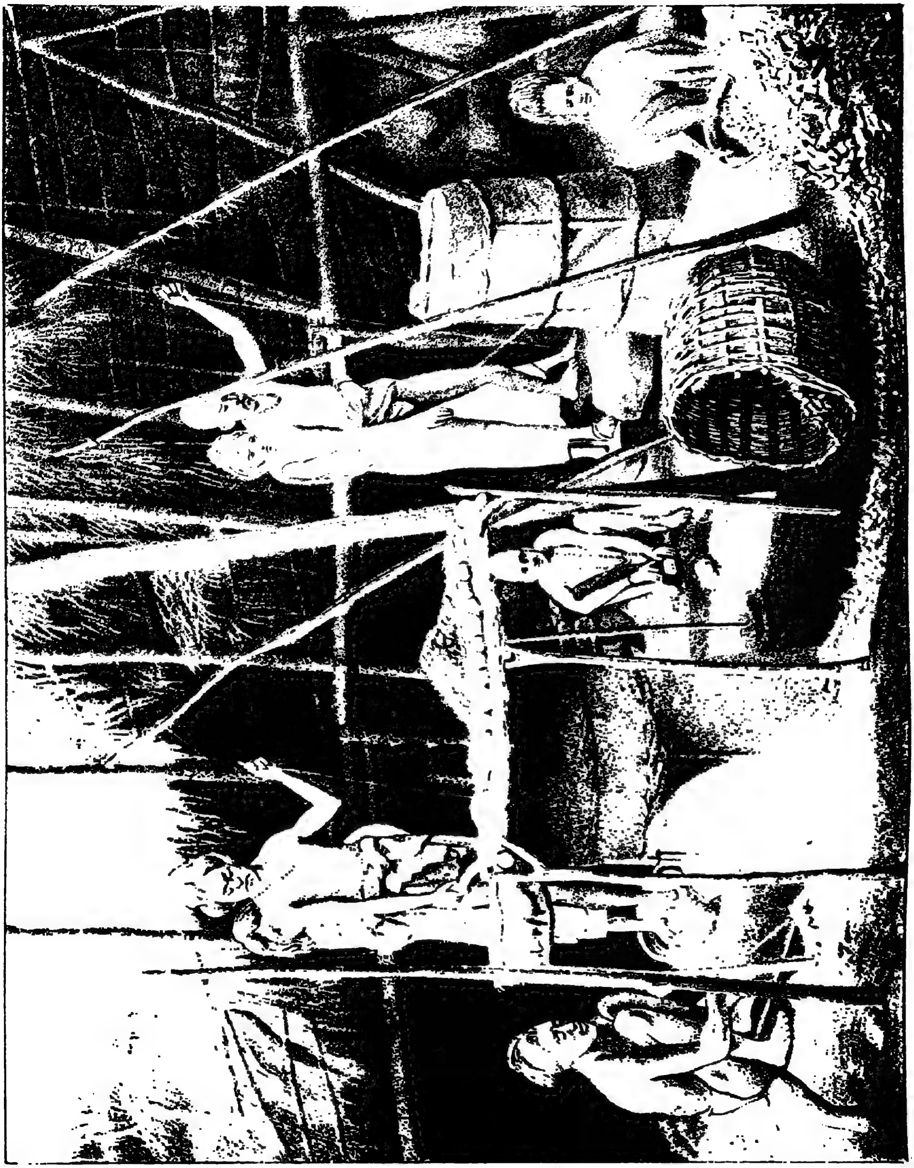
Table showing character of Iron Ores collected and examined "in situ" in Palamow.

Locality.	Formation.	Percentage of Iron.	Name of Ore.	Mode of occurrence.	Remarks.
Assayed—					
Aurunga.					
1. Rajbar	Barakar	49·2	Red and brown hæmatites	Bedded; concretionary structure.	These all occur in the outlying area between Balunagur and Chiru; the proper position, no doubt, for iron works.
2. Palee river, section north of village.	Barakar	45·3	Brown hæmatite	Do. do.	
3. Kurmahee	Barakar	56·6	Red ,,	?	
4. Dudhuria	Barakar	33·7	Black band, with free carbon	Bedded	
5. Ghotam	Barakar	39·4	Red hæmatites	Do.	
Hutar.					
6. Hills east of Sindhorwah	Barakar	59·3	Brown ,,	Concretionary in sandstone	These, though good ores, do not occur with sufficient regularity or abundance to be of value.
7. Hetlee	Barakar	43·5	Red and brown hæmatites	Ditto ditto	
8. Hurilong	Barakar	45·3	Brown hæmatite	Ditto ditto	
9. Neturhat	Laterite	45·5	Ditto	Bedded	An excellent and abundant ore, but occurs too far away from the coal-fields to be of much value.
Not assayed—					
Aurunga.					
10. Kolherwan, south of village	Barakar	...	Sandy concretions of red and brown hæmatite.	Bedded	These occur in the vicinity of Nos. 1 to 5, but are of inferior value.
11. Hills south-east of Bijrah	Barakar				
12. Hooshloo	Barakar				
Hutar.					
13. Korom Toleh	Crystalline or metamorphic		Brown hæmatite	?	Used by the Agarias.
14. Kurahi, north of Chongo	Crystalline or metamorphic		Nearly pure magnetite	Irregular lodes and bands in hornblendic rocks.	Smelted by lohars of Chorhut.
15. South-west of Kopeh	Crystalline or metamorphic		Ditto	In granite veins	This is of no commercial value, but is smelted by the Agarias.
16. Do. do	Crystalline or metamorphic				
17. Do. of Monodag	Crystalline or metamorphic		Ditto	Irregular lodes and bands in hornblendic rocks.	Abundance unascertained.
18. Rajhera, east of Mylee River	Crystalline or metamorphic				
19. Lankha, near Kopeh	Crystalline or metamorphic		Ditto	Ditto ditto	Fragments of ore strewn over a wide area.
20. Herhun	Crystalline or metamorphic		Ditto	Dtito ditto	This is the most promising deposit of magnetite.
21. Morwale	Crystalline or metamorphic		Magnetite, partly altered into red hæmatite.	Occurs with fault rock	Abundance unascertained.
22. Hosir	Crystalline or metamorphic				
23. Satbarwah	Crystalline or metamorphic		Ditto ditto	Found as loose gravel	Probably valueless.
24. Kotam	Crystalline or metamorphic				

It would have been an endless task to have attempted in these pages to have given an account of the local methods of iron manufacture practised in different parts of India. There are variations in details as regards almost every particular of the process. In connection with the Plate No. V, which is taken from a photograph, the following account is given as being typical of the method generally, but by no means universally, practised in Western Bengal, Orissa, and the adjoining districts of the Central Provinces.

The furnaces of the Agarias are built of mud and are about 3 to 4 feet high, tapering from a diameter of about 2½ feet at base to 1½ foot at top. The hearth is a rounded cavity, which is about 10 inches in diameter, and the circular shaft above it is 6 inches in diameter. A bed of charcoal having been rammed down into the hearth, ignited charcoal is placed above it, and the shaft is filled with charcoal. The blast is produced by a pair of kettledrum-like bellows, consisting of hollowed drums of wood, with goats' skins attached, and nozzles of bamboo. The skins are elevated by the tension afforded by the sticks with strings attached, which are stuck into the ground as represented in the plate. By throwing his weight alternately from one side to the other the operator, who stands on the leather, overcomes the tension, and his heels act as stoppers to the valves which admit the air into the bellows.

In the cases figured additional weight is given to the bellows by the operators' wives standing behind them. The bamboos which convey the blast are luted into clay tuyeres, which are themselves luted into the front of the furnace. The blast is, when once started, kept up for six hours, the people engaged changing places from time to time. Powdered ore is sprinkled in alternate layers with charcoal on the top of the charcoal in the shaft, as soon as it is fairly ignited, and as slag is formed it is tapped by a hole, which is every time pierced for the purpose in the side of the hearth, at different levels as the smelting proceeds, and is again closed with lumps of well-kneaded clay. For ten minutes before the conclusion of the process the supply of ore and fuel from the top is stopped, and the bellows are worked with extra vigour. The clay luting of the hearth is then broken down, and a *giri*, or ball of semi-molten iron, including slag and half-burnt charcoal, is taken out and immediately hammered, by which a considerable proportion of the included slag, which is still in a state of fusion, is squeezed out, and the ball is then half-cut in two to show the quality of the iron. In some cases by several re-heatings in open furnaces and by hammering, the Agarias refine this into iron fit for market, but in others they dispose of the *giri* to the *lohars* who work it up into bars. Although the trade in



iron is a profitable one to the merchants, nothing can exceed the miserable state of indigence of the Agarias, who, in spite of their working hours being sometimes from 12 to 15 hours long, when they make two *giris*, earn barely sufficient to keep them alive. Four annas is a common price paid for one of these *giris*, which represents the outcome, not only of the labour of several persons for six hours at the furnace, but also the labour of collecting ore and fuel, &c. In many cases, too, they have to pay royalty out of this miserable wage.

In the volume, quoted above, statistics are given as to prices of the finished iron, but there is always great difficulty owing to varying weights, the advance system, &c., in obtaining these with accuracy. It is stated that as much as Rs. 9 a maund has been paid for the finished iron at Dehri.

Tributary States.—In the Tributary States of Chutia Nagpur the manufacture of iron is carried on by scattered colonies of Agarias, but, so far as is known, there are no features in the industry which call for special notice, save that, according to the Statistical Account of Bengal, the iron of Jashpur is highly prized for the manufacture of weapons and tools, and that it is exported to some extent for this purpose. The ore is possibly chiefly derived from the laterite, which is particularly abundant in Jashpur. The production of iron in the Gangpur State is intimately connected with that in the Sambalpur district, and may therefore be most conveniently mentioned with it.

Central Provinces : Sambalpur District.—The iron ores of Sambalpur, and the furnaces used in their reduction, have been the subject of several papers published during the past fifty years.[1] In a communication received from Mr. Babington by the Asiatic Society in 1843[2] the mines at Kudderbuga, north-east of Sambulpur, are described. It is stated that the annual outturn amounted to one thousand Calcutta maunds per annum. The better qualities of iron were sold at the rate of Re. 1-2 per bazaar maund (=60 lbs ?). The custom of sacrificing a goat to Gauttailee, the goddess of the mines, on the occasion of the erection of a new furnace, is mentioned and is of interest in connection with what has been said on the same subject in reference to diamond mining (see page 50). Dr. J. Shortt, in 1855,[3] described the process of manufacture and mentions that there was a considerable and profitable trade between Sambalpur and Cuttack. In the Central Provinces Gazetteer[4] it is stated that, notwithstanding the abundance of iron ores throughout Sambalpur, Rehrakol is the only part of it in which smelting

[1] Gleanings in Science, Vol. III, 1830, p. 330, &c.
[2] Jour. As. Soc. Bengal, Vol. XII, p. 164.
[3] Selections from Records, Bengal Government, No. XXIII, p. 184.
[4] Pages 224-249.

is carried out to any extent. But this is not quite correct, as will be seen from the account given below. The chief of the smelters in Rehrakol is a Chawan Rajput by caste. There are about ten villages devoted to the manufacture; as usual the Lohars are badly off and much indebted to the traders, who despatch the metal to Cuttack, where its sale is highly profitable. The Raja is said to derive but little income from this source.

The ore used at Kudderbuga, which was alluded to above, is derived from bands of decomposed magnetite in the metamorphic rocks and the detritus from them.[1] In the sedimentary rocks of the Raigarh and Hingir coal-field there are several sources of iron ore belonging to different horizons; of these two, or perhaps three, are included in the Barakar group. The most abundant source of ore is apparently at Kodaloi and other points on the same horizon. The following remarks on the subject refer to the condition of the industry in the northern part of Sambalpur as it appeared in the year 1875.[2]

In the upper (Hingir) sandstone series ironstones occur, but are seldom used by the native Lohars or Agarias. In several instances it was found that Lohars of villages, which, owing to wood being abundant, were situated within the upper sandstone area, procured their ore from the Barakar rocks, some miles distant. Except towards the frontiers of the Hingir highlands, there are few Lohars' villages in that zemindari, but in no part of the country visited are they so abundant as in Rampur. At many of the large villages there are furnaces, but the greater number are worked by colonies of Lohars, who form temporary villages where timber is abundant, passing to new localities when they have exhausted the supply in their vicinity. Although *sál* (*Shorea robusta*) is the wood most commonly used for making charcoal, the bijasal (*Dipterocarpus marsupium*) seemed to be preferred by some. Bamboo, though abundant, is never used. The wood is cut into logs, about 3½ feet long, or rather more, and is burnt in holes dug in the ground, which are about 4 feet square and 18 inches deep. Small branches are not used, only the very best of the timber. The furnaces are somewhat smaller than those used in Palamow; they are furnished with a tray above, in which a quantity of prepared ore and charcoal is kept, which can be raked into the top of the furnace by the person working the bellows without further assistance. Differing from the practice in Hazaribagh, the same individuals make the *giri* (bloom), and also work it up into saleable refined iron. The *giris* are much smaller than those in Hazaribagh, ranging in weight perhaps from 6 to 10 seers. So far as could be made out, the mahajans get

[1] Records, G. S. I., Vol. X, p. 182.
[2] *Op. cit.*, Vol. VIII, p. 120.

from 15 to 20 seers of iron for a rupee from the Lohars, but owing to the advance system, &c., this could not be accurately ascertained."

Besides what has been said about Rehrakol, there is nothing remarkable or worthy of special note, so far as is known, in the production of iron in the Native States of Chatisgarh. According to the census returns of 1872, there were then in the Sambalpur district and its seven Feudatory States altogether 3,023 persons engaged in the manufacture and in the working up of iron into rough tools and weapons.

Bilaspur District—The only available information on the production of iron in this district is contained in the Central Provinces Gazetteer. The sources from whence the ores are obtained are probably similar to those in Sambalpur, as rocks of the same age occur there.

There are said to be only forty furnaces in Bilaspur, with a total estimated outturn of 400 maunds, but as the total consumption is three times that amount, the deficiency has to be made up by imports from Mandla and Sambalpur. The retail selling price is said to be Rs. 13 per maund, or say Rs. 273 per ton. Ore is abundant, but the limited number of Agarias prevents an increase in the local production.

Raipur District.—Little or nothing is recorded as to the iron ores of this district. Throughout the central parts, even were ore abundant, fuel is so scarce that it would be impossible to work it.

Mandla District.—Captain Pearson[1] speaks of iron ore as being abundant in this district. It is worked by Agarias who occupy numerous villages at the foot of the Amarkantak plateau, and in the south-east corner near Umerwani, near the sources of the Seoni and Bormeyer rivers. According to the Central Provinces Gazetteer, the ore is laterite, and the best metal comes from mines near Ramgarh. There are also good mines in Mowai, the ore from which is used in the manufacture of iron for local purposes. As above stated, Mandla exports iron to the adjoining districts of Bilaspur.

Bhandara District.—The geological relations of the iron ores of this district are not known, but it is possible that laterite affords the supply. The principal mines are stated to be in the Chandpur, Tirora, and Pratapgarh parganas; they are mere pits 10 or 12 feet deep. The people engaged in the work are Gonds, Goaras, Pardhans, and Dhimars. The amount manufactured is more than sufficient for local wants, so that iron is a regular article of export. The mines at Agri and Ambaghari, in Chandpur, yield an ore from which a very tough but malleable metal is produced.[2]

Balaghat District.—Ores of iron also occur in this district and are smelted by the Gonds. The metal is sold in rough semicircular masses

[1] Report on the Mundla District, 1860, p. 21.

[2] Central Provinces Gazetteer, p. 59.

called *chulas*, which average 10 lbs in weight, at the rate of two to four a rupee.

Jabalpur District.—According to the Central Provinces Gazetteer, iron is found in more than a hundred places in this district, of which the principal are Simra, Gogri, Bolia, Agaria, Dalrora, Jauti, Panagarh, and Lameta. The ores are stated to be as follows:—(1.) detrital (? laterite ore); (2.) from Gondwana sandstones; (3.) ores from sub-metamorphic (or Bijawar) rocks; (4.) ores accumulated along fault lines.

To the last belong the hæmatite ores worked in the mines at Dubwara, Agaria, and Jauti. They are by far the most productive, No. 3 ores are next in importance; they are mined at Lameta, Panagarh, &c. Among the more important iron mines in the Jabalpur district are those of the Kumbhi pargana, about 20 or 30 miles to the north-east of Jabalpur. The ore occurs, it is said, in the form of black iron sand, and is known by the name of *dhao*; it is manufactured into various utensils at Panagarh.

Mr. Hacket, as quoted by Dr. Oldham,[1] states that the iron ores of Jabalpur occur altogether in the Lora group of the Bijawar series, excepting those obtained from the laterite of Bijaragugarh. The most important mines are at Jauti or Jauli, others at Gogri, &c.; from Jauli alone, 50 loaded buffaloes, each carrying 3 maunds of the ore, used to be despatched daily. The ore, which is a micaceous iron with massive hæmatite, yielded on assay 68·5 per cent. of iron. Mr. W. G. Olpherts, C.E., has taken a lease of these mines from Government, and the mineral paint, of various colours, which is now well known in India, is prepared by grinding this ore to an impalpable powder between stones worked by water-power.

The following, giving the cost of production of one maund of bar iron by the native process, is from information kindly supplied by Mr. Olpherts:—

	Rs. A. P.	Rs. A. P.
6 maunds iron ore	0 4 0	
6 „ charcoal	2 0 0	
2 coolies	0 10 0	
		2 14 0
This yields 3 maunds *kachcha* iron, the refining of which costs—		
4 maunds of bamboo charcoal	2 0 0	
10 coolies	1 4 0	
		3 4 0
Total cost of one maund of iron		6 2 0

[1] Records, G. S. I., Vol. V, p. 9.

As the selling value of this is Rs. 8, a fair margin is left for contingencies and profit. Recently Mr. Olpherts has been making experiments with a view to the production of charcoal-iron by the application of European methods.

At Palle (Pullee) the excavations for ore were, in 1872, 100 yards long by 30 yards wide by 50 deep. The mines at Mungela and at Agaria in the Majgoan hills, and also in the hills west of the marble rocks, are all situated on the same geological horizon, and the deposit of ore appears to be constant and to offer an unlimited supply of the best quality.

Narsinghpur District: TENDUKHERA OR OMARPANI.—The ores at Omarpani have long attracted notice owing to the excellent quality of the iron produced from them at Tendukhera. They occur in association with much disturbed limestones and quartzites of Bijawar age, but the precise mode of occurrence is somewhat obscure. There appears to have been some faulting of an interstratified bed of ore, and besides this fissures and cracks appear to have become filled with the ores which consist of very hard earthy brown and red hæmatites with occasional masses of specular iron. The mines consist of irregularly distributed pits and burrows, which follow the courses of the ore to depths of from 40 to 50 feet till work is stopped by the influx of water. The ore is carried to Tendukhera, 2 miles distant, where it still continues to be smelted, although the charcoal has to be brought from very long distances.

Mr. J. G. Medlicott[1] attributed the good quality of the metal which was produced here to the fact of the ore being slightly calcareous, which produces the same effect as would a purposely added flux. The metal commanded a higher price than any manufactured in any other part of the Narbada valley. The ores being generally similar in character, and the system of working them not varying in any important respect, there can be little doubt that this is the true explanation.

As to the abundance of this ore there seems to be little reason for doubt that it is considerable, but to work it on the large scale a regular system of mining would have to be adopted, as it is less readily accessible than are most Indian iron ores. These mines were leased, together with the coal mines at Mopani, to the Narbada Coal and Iron Company, but they have never manufactured any iron, although they originally intended to do so. And indeed it was one condition of their mining lease that they should do so by a definite time, *i. e.*, 5,000 tons of

[1] Selections from Records, Government of India, Vol. X, p. 25.

marketable iron were to have been produced within five years of the opening of the railway to Jabalpur; this period lapsed in August 1872.

When visited by Mr. Blackwell in 1857, there were about 70 to 80 furnaces in Tendukhera. The charcoal was made in the jungle, from 4 to 10 miles to the north, and was brought to the town in baskets borne on the backs of buffaloes, costing on delivery 8 shillings per ton. The same authority states that there were two kinds of iron which were made in different furnaces, the terms *kachcha* and *pakka* having a special and local signification, and not referring, as they do elsewhere, to different stages of preparation of the same metal. The *kachcha* iron was said to be turned out in blooms of marketable iron, the furnaces more nearly resembling the Catalan than any other he had seen in India. The *pakka* iron was made in a furnace of a different form, from which it came in the condition of crude steel and by hammering was brought to the condition of tough iron; the crude steel was used for making edge-tools. There is probably a mistake in this account, as at present the iron is sold either in the form of roughly hammered blooms, or it is worked up after several heatings, in an open furnace, into refined iron.

The prices, according to Mr. Blackwell, were in 1857: *kachcha* iron, Rs. 3½ to 4 per gond of three local maunds, or £3-3 to £3-12 per ton; *pakka* iron, Rs. 5 to Rs. 6 per gond of three maunds, or £4-10 to £5-8 per ton. In 1873, the price of the latter was about £6 per ton. The outturn in 1857 was about 800 tons per annum.

The following were the proportions of ore and fuel which were used respectively:—

	Iron Ore.			Charcoal.		
	Tons.	Cwt.	Qrs.	Tons.	Cwt.	Qrs.
Kachcha iron	3	9	0	3	15	0
Pakka „	5	3	2	5	12	2

One of the best account of these mines and furnaces is by Captain Franklin; it was written in 1827, but does not appear to have been printed. Captain Franklin was specially engaged at the time as Surveyor of iron mines in Sagar and Bundelkhand. His account of the method of making steel as witnessed by him was as follows: Three seers weight was cut from an ordinary bloom, from which some iron had already been prepared. It was first exposed to the heat of a common forge, just short of fusion; it was then hammered slightly, the process being repeated eight times; after the third time the red-hot mass was always rolled in the ashes of burnt cowdung previous to hammering; after the eighth hammering it was heated red-hot and plunged into water; it then weighed 1 seer and 9 chittacks, and was an excellent steel.

According to the natives, the best charcoal for smelting was that made from the mhowa tree (*Bassia latifolia*), and for refining that of either bamboo or teak; but the best for steel was prepared from resinous wood, such as that of the Dhow (*Conocarpus latifolia*) or the Kair (*Acacia catechu*).

Captain Franklin made suggestions with reference to the introduction of simple machinery in order to produce iron suitable for such work as making suspension bridges, &c. In the year 1830 Colonel Presgrave opened a suspension bridge over the Bias river in Sagar, the iron for which had been all smelted at Tendukhera.

Iron ores occur also in the Sagar, Damoh, and Hoshangabad districts, but they are perhaps not of sufficient importance for special notice here, though there are materials available for the purpose. In the first-mentioned district a very pure and massive red hæmatite occurs in nests in rocks of the Bijawar formation, and brown hæmatite in bands is found in the metamorphic rocks.

Chanda District.—In the year 1855 Messrs. Hislop[1] and Hunter drew attention to the extraordinary richness and abundance of the iron ores in this district. Near Dewalgaon there is a hill named Khandeshwar, which is 250 feet high, and the whole mass is laden with ore. With the abundance of fuel available it was considered that this hill alone might furnish the whole of India with iron. Among other localities, at Lohara, Ogulpet, Metapur, Bhanapur, Menda and Gunjwahi, most of the ore was hæmatite, but magnetic ores were also found. Rich lateritic ores were to be found and were then largely used in the native furnaces. Such was the information regarding this district up to the time when the geological examination was commenced by the Geological Survey, since which time the subject has been dealt with in a practical manner, and has given rise to a considerable amount of literature. As a summary of what had been done up to 1877, Mr. Hughes' memoir on the Wardha valley coal-field affords all the information necessary for reproduction here, but for fuller details reference should be made to the papers noted below[2] :—

"(1) The Chanda district surpasses all others in the Wardha valley for richness of iron ore;

"(2) The most noted localities are Dewalgaon, Gunjwahi, Lohara, Pipalgaon and Ratnapur;

[1] Quar. Jour. Geol. Surv., Vol. XI, pt. II, p. 345.

[2] Central Provinces Administration Report, 1861 to 1879. Supplement to *Gazette of India*. 1871, p. 1341. *Op. cit.*, 1874, pp. 1454. and 1847. *Op. cit.*, 1875, p. 288. Mem., G. S. I., Vol. XIII, pp. 109 and 145.

"(3) The most accessible to Warora are Ratnapur, Pipalgaon and Lohara, and among these Pipalgaon;

"(4) The varieties of ore are, at Pipalgaon, compact crystalline hæmatite with some magnetic oxide; at Lohara, the same; at Ratnapur, brown iron ore;

"(5) The great value of these main deposits lies in the almost total freedom of the ores from phosphorus;

"(6) The largest deposit is that of Lohara, but there is also an enormous amount of iron ore at Pipalgaon."

In a previous paper Mr. Hughes described the Lohara hill as consisting of compact crystalline hæmatite with some magnetic oxide. It is fully three-eighths of a mile in length, 200 yards in breadth and 100 to 120 feet in height, and it is believed to be traceable beyond the hill portion for a considerable distance.

At Pipalgaon, lat. 20° 23′ N.; long. 79° 34′ E., an excessively fine mass of red hæmatite, resembling that at Lohara, is seen three-fourths of a mile east of the village. The strike of the lode is west-north-west to east-south-east.

At Ratnapur, lat. 20° 23′ N.; long. 79° 37′ E., there is a rich lode of brown iron ore which forms a terrace on the north side of the small range of hills facing Alisur. This lode is in places 40 to 50 feet wide.

The following analyses illustrate the composition of these ores:—

LOHARA (*Mr. David Forbes*).[1]

Iron, metallic	69·208
Oxygen in combination	29·376
Manganese sesquioxide	·090
Silica	·823
Alumina	·432
Lime	·054
Magnesia	tr.
Sulphur	·012
Phosphorus	·005
	100·000

An assay of the same ore by Mr. Tween gave 70·00 per cent. of metallic iron.

[1] *Vide* Colliery Guardian, 13th September 1873.

PIPALGAON (*Mr. Ness.*)

Protoxide of iron	63·0	Metallic 71·05
Peroxide of iron	31·5	
Lime	·5	
Magnesia	tr.	
Phosphorus	„	
Sulphur	„	
Silica	4·5	
Water, traces and loss	5	
	100·	

RATNAPUR.

Analysis by Mr. Ness—	
Metallic iron	49·7
Insoluble	26·0
Analysis by Mr. Tween—	
(*a*.) Metallic iron	50·5
Insoluble	22·8
(*b*.) Metallic iron	52·0
Analysis of laterite near Ratnapur—	
Metallic iron	25·7

The great obstacle to the manufacture of iron here is the quality of the fuel; *vide* page 92. Limestones of good quality and well suited for flux abound in the Wardha valley. The following assays are given by Mr. Hughes to illustrate the character of the stone from the two principal sources, and kankar, containing a high percentage of carbonate of lime, is also obtainable :—

	Vindhyan limestone.	Lameta limestone
Carbonates of lime and magnesia	96·8	94·5
Oxides of iron and alumina	1·2	3·0
Phosphoric acid	tr.	tr.
Insoluble	2·0	2·5
	100·0	100·0

The following account by Mr. Hughes of the experimental iron manufacture at Warora is quoted *verbatim* from his memoir. The comments of practical iron-masters on the results described by Mr. Ness are of special value and importance :—

"The opening experimental trial by Mr. Ness, to determine the adaptability of the coal and iron ore of the Chanda district to the manufacture of iron on a commercial scale of some magnitude, was made 'from the 26th to the 28th August 1875. On the latter date, from the giving way of one of the tuyeres, and allowing water to get into the hearth, it got so cold that the furnace had to be let out, at which time about 2 cwts. of iron had been reduced, and was afterwards taken out of the hearth in one solid piece. The *second* trial with this furnace was commenced on the 21st and was closed on the 25th September 1875.'"

The experiments were conducted in the same manner in both cases, and were as follows[1] :—

"The furnace, after being thoroughly dried, was filled for about three-fourths of its capacity with rough, dry timber, and then fired. On the top of this a few feet of charcoal were placed, and then regular charges of iron ore and coal, &c., were made, consisting of 1 cwt. coal to ¼ cwt. of Lohara iron ore, ¼ cwt. Ratnapur iron ore, 20 lbs. limestone, and an occasional blank charge of coal or charcoal. This course was continued until the furnace was full. In 24 hours after lighting the furnace, the molten slag began to come down into the hearth, then blast was let on quietly, and three hours thereafter the slag made its appearance at the cinder notch. The pressure was increased to about 1½ lbs. per square inch on the second day. During this time the slag formed, and came off in larger quantities, and the hearth quickly filled with spongy iron which would not liquify. To overcome this hinderance, the blast was intensified, and more blank charges of coal were added. The temperature in the hearth increased and the fire-bricks, the tymp plate, and even the bottom of the hearth, were fused; still the iron that had settled down was so mixed with the ashes of the coal that it would not liquify, and only kept accumulating till the iron reached the top of the tuyeres, and then a stop was put to all further proceedings till the mass was dug out, which was over a ton in weight."

"Describing this first assay at iron-making to the South Staffordshire Mill and Forge Managers' Association, in a letter, dated Warora, 5th November 1875,[2] Mr. Ness gives the analyses of the iron ores and coal, and then says—'You can easily calculate from the analyses I have given that the gross amount of foreign matter that would require to go into the furnace to make a ton of iron is not much in excess of many of the mixtures in use at home. I started the furnace in the

[1] Public Works Department Proceedings for May 1876.

[2] Mining Journal, 25th December 1875.

usual way, possibly giving it a better chance in having it thoroughly dry, and filling it three-fourths full of dried timber before lighting it, and then filling regular charges of coal, limestone, and ore in the proportion of 2, $\frac{1}{6}$, and 1, respectively, with $\frac{1}{8}$ charcoal [1]; blast[2] was let on gently after the first appearance of slag before the tuyeres; afterwards it was increased to a little over 3 lbs. pressure to the square inch, and to about 500 cubic feet per minute in volume. At the end of the time named, I found the hearth full of spongy iron, and though I raised the temperature by blank charges and extra blast till I melted even the fire-bricks forming the hearth, yet the iron would not liquify. On cooling down the furnace to get the mass of iron out, which was over 30 cwt., I found a great portion of it similar to what a puddled ball would be if it were left without being shingled. A number of pieces were cut off and worked in a smith's forge without any great difficulty. In the mass of iron in the hearth were embedded pieces of ashes from the coal which had dropped down and passed the tuyeres without being fused. At the tunnel-head I noticed that the coal rapidly decrepitated, which is doubtless due to the quantity of moisture it contains. This impoverished coal then descended to the zone of fusion just above the tuyeres, with little or nothing left to do the work required of it."

"The sectional diagram, which was communicated with the paper, showed that the furnace was 24 feet high; that the top of the bosh was 6 feet 6 inches in diameter; that the top of the hearth was 2 feet 6 inches diameter, and that the bottom of the hearth was 2 feet diameter. The throat of the furnace was 3 feet 10 inches diameter, and the tunnel-head 5 feet 6 inches; the tuyeres were 2½ feet diameter in the nozzle, the hearth about 3 feet 6 inches deep. The blowing engine is a small horizontal one, with a receiver intermediate between the engine and the hot-air stove, which has four pipes. The air is heated with an ordinary grate and stove.

"In the discussion that took place after the reading of Mr. Ness' letter, one speaker showed how coal, not greatly inferior to that with which Mr. Ness had to deal, had been made available for blast furnace purposes, by holes being made in the furnace above the tuyeres and against the bosh, and the accumulated ashes and cinders raked out (two or three cart-loads at a time, three or four times a week). In this way the manager kept his furnace from 'gobbing.' The quality of the iron

[1] Whilst working, blank charge of coal in every 10 to 16 charges was added.

[2] Temperature of blast 150° Fahr. The heating apparatus was mainly to dry the air, as when the experiments were made the air was saturated with moisture, the monsoon not being over.

suffered by the coal, and the yield was less. The coal of which he had been speaking was that known as the 'mealy grey,' or the bottom coal seam of Staffordshire. With the Indian coal it was thought to be impossible to smelt the rich Indian ore in other than small quantities without an abundance of fluxing materials. A due admixture of the *strongly silicious* with the rich metallic ores of India would, it was assumed, contribute to this end. Even the majority of the coals of Staffordshire were too weak to carry a heavy burthen of iron stone, and some of the members believed that Mr. Ness would best succeed by beginning his experiments with smaller furnaces.

"Other members, however, thought that the height of the furnace might be increased with advantage. It was also pointed out that though Mr. Ness had spoken of having well-aired his furnace, and of putting in blank charges, yet that it been found well, in Staffordshire, to consume a whole mouth in such work before a new furnace was charged with its full burden." (*Mining Journal*, 5th February 1876.)

"The chief cause of failure in the attempt to produce iron by the blast furnace system is attributed by Mr. Ness to the unsuitableness of the coal for the purpose. Mr. William Molineux, the President of the Association, agrees with him that the Warora coal contains a large amount of inorganic matter, and says that to deal with such coal considerable skill and experience is required. He also thinks that the position of the tuyeres in the furnace might be improved.

"It appears, from observations made by Mr. Ness, that the coal did not retain more than one-third of the fixed carbon it had when charged, by the time it reached the zone of fusion; and this feature of its behaviour, together with its tendency to decrepitate, and the large amount of ash that it contains, led him to condemn its use in a blast furnace. The coal is evidently unfit to reduce hard refractory ores like those of Lohara and Pipalgaon; with the softer ores of Bengal and Dechauri (Kumaun) it would probably answer.

"After the completion of his preliminary trials with the blast furnace, Mr. Ness put up roughly a small reverberatory furnace, to see the action of the coal when burned on a separate grate, whether it was capable of melting and boiling grey cast-iron. Although the trial furnace was of a rude description, and without a proper reverberatory arch, the time taken, and the quantity of coal used, did not appear to be much in excess of what is commonly required for such purposes. This result convinced Mr. Ness 'that, with a regenerative furnace, both quantity and intensity of heat can readily be obtained from Warora coal for the reduction of the iron ores by a direct process.'

"The last experiment has been to pulverise the ore, mix it with milk of lime, make into balls, and expose to the heat of the reverberatory furnace. This plan answered very well." (*Mining Journal*, 26th February 1876.)

Mirzapur District.—So far as is known, there are no especially abundant sources of iron ore in this district. The principal ores are magnetites, which are found in bands in the metamorphic rocks and the ordinary concretionary nodules and bands in the sandstones of Barakar age. The former are worked by the natives, according to Mr. Mallet[1] at Korchee close to the Panyun stream to the east of the Gonda hill. At other localities the deposits are of less extent; magnetic sand is common in many of the streams, but is not used.

Rewah.—There is little detailed information as yet available regarding the extent of the iron deposits in Rewah. Here and there there are native furnaces scattered about, and it is believed that the ore, which is principally used, is derived from the coal-measure rocks. Some information on the iron industry in Singrowli, in the year 1854, will be found in a paper by Mr. W. Roberts,[2] but it offers no information worthy of special notice, save, perhaps, the fact that Mr. Burke, who had charge of the coal mines at Kota, succeeded in making iron from ore obtained at Hindowa, which was superior to that made by the natives, but it did not fetch a remunerative price in the market.

Bundelkhand.—There are two principal sources of iron ore in Bundelkhand; these are the laterite and the rocks of the Bijawar series; the latter is the most important. The inferior lateritic ore used not to be much worked by the natives, except in the hills to the north of Simereah. It was not considered by Mr. Medlicott[3] to be sufficiently abundant to be worked on the large scale. The Bijawar ore is similar to that of the Narbada valley, being a sub-crystalline red hæmatite; but it has the superior advantage of being more easily worked, being associated with soft rock, and is itself generally purer.

Banda District.—In this district there are mines at Gobarhai, Deori, and Khirani.[4] Those at Gobarhai are situated on the top of a hill, 1½ mile from the furnaces. In some parts of Bundelkhand Mr. Medlicott states that the positions of the furnaces show that they have receded gradually from the mines as the fuel has been used up.

[1] Records, G. S. I., Vol. V, p. 22.

[2] Selections from Records, North-West Provinces Government, new series, Vol. III, p. 149.

[3] Mem., G. S. I., Vol. II, p. 89.

[4] North-West Provinces Gazetteer, Vol. I, p. 97.

In the refining furnaces at Gobarhai charcoal made from the bamboo is alone used.

Lalatpur District.—At Salda, in the Maraura pargana, a pure hæmatite is found, and soft iron is smelted from it, which is exported to Sagar, &c. There were, in 1874, 53 furnaces at work, for each of which an average annual payment of Rs. 5 was made to the Forest Department on account of the timber used for charcoal. This iron is sold at from 10 to 20 seers for a rupee. But another kind, called *kheri*, is prepared at Pura and is of a steel-like character.

Central India : Bijawar State.—In this State, as also in Panna and some others in the Central Indian Agency, iron ores are worked to a greater or less extent. Hirapur[1] in Bijawar was formerly, if it be not still, a principal centre of manufacture. There were iron mines also in several localities near the Kane river. The most important deposits in Central India, however, are believed to be those in Gwalior.

Gwalior.—The rocks of the Gwalior series, in the State of the same name, which constitutes the territory of the Maharaja Sindia, contain several remarkably rich deposits of iron ore. These were formerly extensively worked, but are now more or less deserted in consequence of the distances to which the ore has to be taken to the furnaces which are situated near the fuel. The following are the principal iron mines mentioned by Mr. Hacket[2] :—

Par Hill, Lat. 26° 2′ 30″; Long. 78° 5′.—The beds near the top of this hill consist of variegated clays in which the iron ore occurs in thin laminæ. The hill has been extensively burrowed by the miners and a large proportion of it has, in fact, been carried away.

Mangor.—This locality is situated in a narrow valley, about 3 miles north-north-east of the Par hill; the ore is of similar character, being on the same horizon. The richest seams are worked by shafts 30 to 40 feet deep, but there are mines at other points too.

Santow, Lat. 26° 6′; Long. 78° 10′.—The workings here are confined to a limited space. The richest seams are reached by shafts from 50 to 60 feet deep, from which small galleries are extended. These ores belong to the same horizon as those at Par and Mangor.

There are smaller mines at intermediate localities, and the ores have a wide extension. The selection of the particular spots is due to the ore being locally decomposed at these places and therefore more easily worked. It is sold at the pit's mouth at the rate of 60 to 70 maunds for the rupee.

[1] Jour. As. Soc. Bengal, Vol. XIII, Proc. VI.

[2] Records, G. S. I., Vol. III, p. 42.

The following detailed statement is taken from a report drawn up by Herr von Schwartz during the present year :—

Name of the Village near the place.	Name of Specimen.	Average contents of iron metallics in per cent.	How many miles from the forests.	How many miles from Gwalior.	Remarks.
Santow	Red iron ore.	66	50	7	Contains partly manganese.
Maesora	" "	60	50	9	These iron ores occur in very great quantities.
Gokalpur	" "	65	50	2	
Dharoli	" "	63	55	8	
Bamaori	" "	66	50	10	
Raypur	" "	71	50	8	
Gokalpur	Magnetic ore.	70	50	2	
Girway	" "	66	50	8	
Besides these there are others of inferior quantity (?)					
Binaori, &c., Baroda .	Brown iron ores.	45	20	45	Contains manganese.
Tonilia		45	...	70	
Sipri & Turwaya .	Silicious hæmatites.	48	34	64	Large quantities.
Goonjars, &c., Baron .	Brown iron ores.	52	20	80	

According to this authority there are but small traces of sulphur and none of phosphorus in these ores.

At about 50 miles to the north-west of Gwalior there is a forest, which, it is estimated, would, without re-planting, furnish fuel sufficient for an outturn of 12 tons of bar-iron a day for a period of 900 years. On the supposition that one square mile of this forest would yield 15,000 tons of timber, the total available amount is calculated to be 56,000,000 of tons; the charcoal is said to weigh 17 pounds per cubic foot, and costs only 4 annas a maund, while the German and Styrian works pay three times that amount for charcoal weighing only 12 pounds per cubic foot.

Fire-clay suitable for making bricks for ordinary purposes has been discovered at Girway, near Tisroan, 35 miles south-west of Gwalior. Limestone is obtainable and the manganiferous iron ore might be employed in the manufacture of *spiegeleisen*.

If the above figures with reference to charcoal can be depended upon, Gwalior certainly seems to offer a promising field for the manufacture, though the distance which the ore would have to be carried is considerable and would be prohibitive if railway carriage were not available; but the experience of Indian forests generally—and especially of those in the comparatively dry region in question—suggests the probability that the above estimate as regards fuel is not to be relied on.

Rajputana.—Iron ores are pretty generally distributed throughout the different States and districts comprised in Rajputana. More particu-

larly noteworthy are the deposits found in Alwar, Jaipur, Udepur, and Ajmir; there are also mines in Bhartpur, Bundi, Jodhpur, Kota, &c.

Alwar State: BHANGARH, Lat. 27° 6′ E.; Long. 76° 21′ N.—Iron ores, consisting of a mixture of limonite, magnetite and oxide of manganese, occur near the base of the Arvali series of rocks close to Bhangarh, where they are extensively mined. A sample contained 59·67 per cent. of iron and 12·7 of manganese. Traces of nickel have been found in these ores. The excavations are several hundred yards long, and in places 20 or 30 wide, and it is evident that an enormous quantity of ore has been taken from them. They at present supply ore to most, if not all, the furnaces in the Alwar State. There are similar large mines at Rajgarh, lat. 27° 14′; long. 76° 40′ 30″; but they are not now worked. The above information is from papers by Mr. C. Hacket.[1] In 1873 Major Cadell[2] wrote regarding this industry, that there were thirty furnaces in the State, which produced 15,000 maunds, or 536 tons per annum.

The charges of the furnace were large and the smelting lasted for 20 hours. The resulting bloom or ball of iron weighed from 200 to 280 pounds. The proportions of ore to fuel, as stated, namely, 520 pounds to 440, are unusual, and suggest some mistake, as in most native furnaces the quantity of fuel bears a much higher proportion to the ore. The sale price of the iron is Rs. 112 per ton, and the profits on the cost of manufacture, of which the details are given, are small, having to be divided between the families, including some 60 or 70 persons per furnace. The royalty is 10 per cent.

In 1875 there were more than 30 furnaces in the State, some of them being situated at Rajgarh, Tahla, and Baleta. One kind of imported iron, locally called *kheri*, is preferred to that made in the country, but costs twice as much. For fine work English rolled iron is used, being neater than the softer country hammered iron.

Jaipur State: KERWAR.—Large quantities of iron ore have been raised at Kerwar, near Hindaun, but the mines are now abandoned in consequence, Mr. Hacket thinks, of scarcity of fuel.

Ajmir District: AJMIR, Lat. 26° 28′; Long. 74° 41′ 30″.—There are some old abandoned iron mines near the jail in the city of Ajmir, but the produce cannot have been considerable.

Udepur State: GANGAR.—An iron mine exists 1 mile north of Gangar and 10 miles north of Chitor. It is in a bed of limonite, with which psilomelane is associated, of from 1 to 5 or 6 feet thick; it is at the junction of the quartzites with the slates. Mr. Hacket considers it

[1] Records, G. S. I., Vol. XIII, p. 248; and Ulwar Gazetteer, p. 183.

[2] Ulwar Gazetteer, p. 80.

probable that an abundant supply of ore could be obtained there. A few furnaces at Gangar are at present supplied with ore from this mine.

There are also some small mines, now abandoned, at Barundui, 1 mile south of Bara Sadri and 20 miles west of Nimach; the ore is limonite.

Central India: Nimar and Malwa.—Indore territory has long borne a reputation for producing iron, and in the "Ain-i-Abkari" the steel mines of Indore are alluded to, together with those of Nirmal in Hyderabad. The principal localities proceeding down the Narbada valley, where there are mines, are at Chandgarh, Ponassa, Barwai, Kandicote, Bagh, &c. There has been much written on the subject of these ores, and their applicability to the production of iron for the manufacture of rails; but at Barwai only, under the energetic and persistent efforts of Colonel Keatinge, did any of the various projects assume a tangible form; and how far even this one failed to realise the object aimed at will be seen from the following.

BARWAI.—The ore at this locality is found in irregular masses of breccia, the matrix of which is chiefly brown hæmatite. It occurs in the Bijawar rocks; it is, according to Mr. Blanford,[1] doubtful whether there is a distinct bed, but it is a rich ore and is found in several places. There are old mines near the villages of Nandia, Korundia, Chutee-Modri, and Karrampura within a radius of 4 or 5 miles of Barwai. In some cases the ore is a pure red hæmatite; in others it is siliceous and would not be easy to work. Samples of ore from Nandia gave from 18·15 to 43·43 per cent. of iron.[2]

In the year 1860 Colonel Keatinge, while on furlough, was deputed to Sweden by the Secretary of State, with a view to obtaining practical information as to the best method of starting iron manufacture at Barwai on the Swedish system; plans were drawn up at Stockholm by Director A. Grill, the head of the Swedish Iron Comptoir, and on his recommendation an accomplished Swedish metallurgist, Mr. Mitander, was selected as manager of the proposed manufactory. A statement, dated September 1861, from which the above facts are taken,[3] gives a number of interesting details in reference to the preliminary arrangements which had been made. The ore of the Nandia mine, which was a limonite found in globular lumps in an ochreous rock, yielded on an average 34·78 per cent of metal, while in the better qualities the average exceeded 50 per cent. Of this ore upwards of 400 tons had been raised, but from another locality, which was christened

[1] Mem., G. S. I., Vol. VI, p. 377.

[2] Blackwell, J. H., 1857. Selections from Records, Bombay Government, No. XLIV. p. 7.

[3] Engineers' Journal, Calcutta, Vol. V, 1862, p. 87.

Mitanderpur, a still richer hæmatite had been obtained, and of it 600 tons had been raised. The flux was a magnesian limestone, which might perhaps have not been well adapted, owing to its containing 19·25 per cent. of magnesia to 32·47 of lime. Fuel for charcoal had been prepared, and the blast furnance, casting-house, rolling-mill, charcoal ovens and calcining kiln, &c., were all in process of erection or were completed, and, after some failures, good fire-bricks had been produced. Soon after it is believed that operations were about to commence, when Mr. Mitander applied for some European assistance, but the Government declined to incur further expense,[1] and the works were offered for sale towards the beginning of 1863, it being decided that in so far as Government was concerned the experiment had gone as far as was expedient. The expenditure up to April 1854 had been £25,000, but although the works were offered to the highest bidder above £5,000 it does not appear that there were any offers, and Mr. Mitander returned to Europe without, so far as is known, having placed the results of his experience on record, at least without having done so in a form which would be of service to any one who attempted again to start charcoal iron works.

It may be of interest to add that Barwai is 39 miles distant by rail from the station of Khandwa on the Great Indian Peninsula Railway. It is 34 miles distant from Mhow, and 47 from Indore.

Bombay: Ratnagiri District.—Throughout the Konkan laterite is widely distributed, and in places it contains rich iron ore, which formerly used to be largely manufactured into iron in native furnaces at Malwan, Vingorla, and other places. Near the first-mentioned locality either magnetic or hæmatitic ores appear to have been also obtained by Dr. Gibson in association with metamorphic rocks. Already, in 1844, competition with English iron and increasing scarcity of fuel was beginning to tell upon the local industry, and it is probably now extinct. Besides the above-named authority, Dr. Royle and Mr. B. G. Shastra have described the iron ores of this region, and the latter has given a figure of the form of furnace in use.[2]

Satara District.—In 1837 Colonel Sykes[3] wrote that the only metallic ore found in the Deccan was of iron which occurs as a nodular hæmatite associated with laterite; it was the ore from which *wootz* or steel was manufactured. The principal place where it was worked was Mahableshwar, near the source of the Kistna.

[1] Proceedings, Public Works Department, 1863-64.

[2] Jour. Bombay Branch Roy. As. Soc., Vol. I, pp. 139 and 436.

[3] Madras Jour. of Lit. and Sci., Vol. VI, p. 364.

Surat District.—Iron ores are reported to occur in the Balsar and Pardi sub-divisions, and there, as also at Bodhan in the Mandvi sub-division, slag, the refuse from former furnaces, has been found; but the trade of the smelter is now no longer practised. Magnetic sand is said to accumulate at the mouths of the rivers, more particularly at the Dumas side of the Tapti.[1]

Kholapur State.—A brief account of the manufacture of iron in this State is given by Major Graham,[2] in his report published in 1854. Three varieties of ore were recognised, namely, *boregale, shilga,* and *tatha.* It seems probable that they were derived from the laterite; they are said to have occurred principally in the districts of Vishalgarh, Cunala, and Kohlapur; the mines were shallow pits, never excavated below a depth of 8 or 10 feet. It is stated that the furnaces were simple holes in the ground, lined with moistened clay and powdered flint. The proportion of metal produced was 33 to 66 per cent. of the ore. This seems incredible and is probably a mistake. It required the labour of 56 men for two days, and an expenditure of Rs. 28, to produce a ton of metal, which sold for from Rs. 37 to Rs. 42; the quality of the metal was bad. The number of furnaces in the State was 30, and the annual outturn of metal 225 tons.

Sawantwari State.—Iron ore is found in the three divisions of this State, but is said to be not very abundant.[3] It appears to be lateritic; it is smelted in small bottle-shaped furnaces. A sketch of one by Mr. Wilkinson is given in Mr. Foote's account of the South Mahratta country.[4]

Panch Mahal District.—Iron ores of considerable richness are said to occur in the Godhra village of Palanpur, and near Jambughora and Surajpur in Narukot. Both in the Panch Mahals and Narukot traces of former smelting works exist, but there are none now in operation.[5]

Kaira District.—There is no information as to the nature and extent of the ores in this district, but large heaps of slag at Kapadvanj testify to the fact that they were formerly worked there.[6]

Rewa Kantha District.—Iron was formerly worked extensively in the western parts of this district close to Jambughora. The ground is so widely covered with slag that it must be concluded that it was the site of extensive iron works. Towards the south of the district, at

Bombay Gazetteer, Vol. II, p. 38.
Selections from Records, Bombay Government, No. VIII, p. 34.
Op. cit., No. X, p. 44.
Mem. G. S. I., Vol. XII, p. 267.
Bombay Gazetteer, Vol. III, p. 197.
Idem, p. 15.

Sunodra, 25 miles west of Nandod, there are large mounds of slag. A sample of this on analysis gave the following result, which testifies to the imperfection of the method of smelting:—

Silica	53·64
Alumina	5·39
Lime	10·49
Iron protoxide	28·96
Loss,	1·52
Magnesia and manganese	tr.
	100

Good ore is said to be found at Bhelod, near Ratunpur, and at Tadkesar, not far south of the Rajpipla border. Piles of slag mark the sites of old furnaces, but the present inhabitants neither know its nature nor origin, nor have they any tradition of iron having been manufactured in that part of the country.[1]

Ahmedabad District.—In this district, too, slag affords the only testimony of the former existence of iron works. The mission-house near Gogha is said to be built on a mound of slag.[2]

Kattywar.—A very complete account by Captain G. Legrand Jacob describes the iron industry in Kattywar, as it was in the year 1838.[3] There were six groups of furnaces, of which two, situated respectively at Ranawao and Ranpur, had been visited by Captain Jacob. The ore appears to be of lateritic age, as it is in some cases obtained by means of pits sunk through the alluvium which indicates a mode of distribution only compatible with the rock being laterite. The positions of the furnaces were chosen with reference to the vicinity of available fuel.

The furnaces were of an unusual shape, as already mentioned in the introduction to this chapter, and indeed, if the figure of one which is given be correct, of very remarkable and exceptional character. From it, and from the accompanying description, it would appear to have been something of the nature of a reverberatory furnace, except in the essential particular that the ore was placed in partial contact, though not mixed with the fuel. The furnaces were long and narrow (dimensions not given), and were built of brickwork lined with clay. At one end there was a chimney, and close to the other extremity there were

[1] Fulljames, Major J. Selections from Records, Bombay Government, No. XXIII, p. 109. Blanford, W. T. Mem., G. S. I., Vol. VI, p. 378. Campbell, J. M. Bombay Gazetteer, Vol. VI, p. 11.

[2] Campbell, J. M. *Op. cit.*, Vol. IV, p. 22.

[3] Selections from Records, Bombay Government, No. XXXVII, p. 465.

two apertures on opposite sides; through one of these the blast from the bellows was driven over the ignited fuel, and by the other the slag was withdrawn. The ore was placed in hollows on a bed of charcoal, and was covered with a layer of the same, but was so arranged as to be on either side of the stream of air.

The bellows consisted of two bullock hides sewn round bamboo hoops in vertical rings and worked alternately by downward pressure, the operator closing the mouth of the sack with his hands as he weighed upon it with his chest and arms. The furnace held little more than seven Bombay maunds, which took from six to eight hours to melt. The Bombay maund was equal to 40 seers, each of which weighed 26 Bombay rupees; the equivalent therefore, taking the rupee at a *tola*, would be about 2 cwt. The metal taken from the first furnace was refined in a second, was then split into equal parts and then wrought into bars; during the manipulation the men used their feet, protected by sandals, almost as much as their hands. Captain Jacob calculated that 40 per cent. of metal was obtained from the ore; the workmen said that the direction of the wind affected the outturn, five maunds being obtained from a double charge of the furnace, during westerly winds, and seven maunds when it blew from the east. This they accounted for by saying that metals were like mortals, some climates agreeing with them better than others. The true explanation was possibly the comparative vigour of the men who worked the bellows under the influence of moist and dry winds respectively.

Captain Jacob says that it was difficult to witness without pain the struggles of these men for a subsistence, which, owing to competition with English iron, was yearly becoming more arduous. His estimate of the total outturn from the six foundries was 150 tons per annum. The best quality was sold at a rate equivalent to Rs. 2-10-6 the Bombay maund. Foreign iron being subjected to a fixed tax, and the country iron being, on account of its superior malleability, better suited for special purposes, were circumstances which combined to keep the industry alive; but Captain Jacob predicted its extinction, and this, it is believed, has actually since taken place.

Cutch.—In the year 1840, Captain Grant[1] described the manufacture of iron in Cutch, which was conducted according to the ordinary Indian method, but the trade was then in a languishing condition, and it has now, owing to competition with English iron and scarcity of fuel, become wholly extinct.

[1] Trans. Geol. Soc. London, Vol. V, second series, p. 293.

The ore which was used is found in the laterite of the sub-nummulitic group, and in some ferruginous deposits near Bhachan. The manufacture was chiefly carried on near Bhachan, where, in 1851, 700 maunds were made. Lunva and Dudhai, in the east of the central plain at Madh, in the west of the province near Vitroi in Vagad, and at Kaura in Pacham island.

According to Sir A. Burnes, the manufacture at the last locality had ceased before 1827. The metal was produced there at the rate of 3½ cwts. to 16 cwts. of ore. Cutch iron is believed to have been of good quality.[1] It is said that *wootz* or steel used to be produced there.

Sind.—Iron ores are not very abundant in Sind, but owing to the want of fuel this is not of much importance. Mr. Blanford[2] states that the most prolific sources of ore are in the passage beds between the Kirthar and Ranikot (tertiary) groups north-west of Kotri, especially in the neighbourhood of Lainyan and east of Bandh Vera. The beds are in many places 15 to 20 feet thick, but only a portion is sufficiently ferruginous to be called an ore of iron. Masses of magnetite, and bands of red and brown hæmatite, occur, however, at many places. The same bed exists west and south-west of Jhirak, but it is not so rich there.

Some ferruginous rocks occur in the beds at the base of the Manchar group, where the latter rests upon the Kirthar limestone near Bandh Vera, and at the base of the Laki range, but, in the presence of the above-mentioned richer ore, it is not likely that this can ever be of much value.

Afghanistan.—In the year 1846, according to Captain Hutton,[3] the supply of iron ore for Kandahar came from Ubbergoon, three days' journey south of Peshawar; it was sold by traders at Pirmul near Ghazni. There were three qualities of metal, which ranged in price, at Kandahar, from 5 to 11½ annas, or double what they cost at Pirmul. The distinction was produced by the number of heatings to which the varieties had been subjected. The duty amounted to one-fortieth of the value.

Magnetic and hæmatite ores are said to occur in the Hazara country, and a clay ironstone in the tertiary rocks at the Bolan. Iron pyrites is found in the trap at many places, but is not used. Sulphate of iron derived from its alteration is collected in some places.

Captain Drummond[4] has described the manufacture of iron in Northern Afghanistan, and pointed out its imperfections at some length.

[1] Wynne, A. B. Mem., G. S. I., Vol. IX, p. 87; and Bombay Gazetteer, Vol. V, p. 19. Raikes, Lieut. S. N. Selections from Records, Bombay Government, Vol. XV, p. 72.

[2] Mem., G. S. I., Vol. XVII, p. 193.

[3] Cal. Jour. Nat Hist., Vol. VI, p. 593.

[4] Jour. As. Soc. Bengal, Vol. X, p. 82.

The process is identical with that in practice in India; he specially comments on the absurdity of carrying the crude or *kachcha* iron to places such as Kabul, where, at a great expenditure of labour and fuel, it loses one-third of its weight before it is converted into the useful article. The carriage of the refuse alone to Kabul costs, he estimates, Rs. 1,000 per annum. It is stated, however, that the Bajaur iron, which was made of magnetic sand, was in great demand in Kabul, and was used in the manufacture of matchlocks at Kandahar; in Kashmir it sold for three times the price of the local iron.

Captain Drummond also mentions the iron of Foormool, which is perhaps the Pirmul of Captain Hutton. It was situated in the Waziri country near Kanigaram, but regarding the iron ores and manufacture of this region we are in possession of some more recent information. During the Waziri expedition of 1860, Dr. Stewart,[1] who accompanied the force, made some observations on the geology. With reference to the iron ores, he states that for days evidences of the iron manufacture, for which Kanigaram had long been famous, had been visible in the form of furnaces, slag, and stores of ore in the villages, but he failed to reach the mines. Subsequently, he forwarded two samples of ore, one of which proved to be limonite containing 40·4 per cent. of metal, and the other was the same ore mechanically mixed with carbonate of lime and contained 31·8 per cent. of metal.

Dr. Verchere,[2] who has described the geology of this region, states that the ore occurs in shaly beds below nummulitic limestone; it is first roasted and becomes black and highly magnetic. As he did not witness the process, nor obtain any information directly from the people, it seems that some caution is necessary in accepting the following statement, as it indicates a different system of smelting from that in practice elsewhere in India. It is stated that in the reduction of the ore a flux made of the nummulitic limestone, or pieces of coral, is employed. In a house at Mackeen, where there were two furnaces, identical with those used in Kashmir, heaps of ore, charcoal and *limestone* were seen, which had evidently been collected for smelting. In spite of the use of this flux the iron is only smelted into a pasty, not fluid, condition, and it is refined by hammering. Their on is soft, but has a tendency to exfoliate. In an account of the process given by Mr. Baden-Powell,[3] no mention is made of the use of a flux.

[1] Jour. As. Soc. Bengal, Vol. XXIX, pp. 317, 319.

[2] *Idem*, Vol. XXXVI, p. 20.

[3] Punjab Products, p. 8.

According to Captain Drummond, this iron cost, at Kabul, only three-fourths of that from Bajaur, the prices being in Dost Mahomed's time Rs. 6 and Rs. 8, and in 1841 Rs. 9 and 12, respectively, for a maund of 48 seers.

Punjab.—Although the noblest specimen of the Indian ironsmith's art, the Delhi pillar, is found within the limits of the Punjab, this province is not notable for the production of iron at present. Iron ores are indeed found in several of the districts, but the Punjab is to a great extent dependent for its supplies of even native metal on neighbouring territories. The facilities for manufacturing iron in the province on the large scale are certainly less than elsewhere, fuel is scarce, and the iron ores are generally not easy of access.

Bannu District.—Iron ores are said to be found in abundance in the hills to the south-east of Bannu. At Kalabagh, the metal from these ores is in great demand for making nails, cooking utensils, &c.[1] Whether the ore occurs in concretionary masses or in beds is not known; it appears to be an earthy hæmatite.

Peshawar District.—The iron ore of Bajaur has long been famous. It is believed to be black magnetic iron sand. As already stated, the iron made from it is exported to Kabul, where it is held in higher esteem than the Waziri iron. The ore is said to be sold in Peshawar and smelted there, when it brings from Rs. 3 to Rs. 6 per maund; it is largely used for making metal for gun-barrels, &c.

Salt-range.—The opinions of both Dr. Fleming[2] and Mr. Wynne[3] are unfavourable to the prospect of any considerable deposit of iron ore existing in the Salt-range. The known ore consists of nodular masses or inconstant layers of an earthy hæmatite resembling laterite.

Jhelam District: Kot Kerana.—The Kot Kerana hills, which do not belong to the Salt-range, are said by Dr. Fleming to produce an abundant supply of hæmatite. Dr. Henderson[4] made some successful experiments with this ore, and produced a few maunds of metal. Fuel has become more scarce than it was in Dr. Fleming's time, and there seems to be no prospect of a profitable manufacture of iron being possible.

Kangra District: Chota Bangahal, Kohad.—An abundant supply of magnetic and micaceous ores of iron are found at Kohad in metamorphic rocks. The preparation of this ore for the native furnaces involves pounding and washing to get rid of the matrix.

[1] Punjab Products, p. 8.
[2] Jour. As. Soc. Bengal, Vol. XVII, pt. II, p. 517.
[3] Memo., G. S. I., Vol. XIV, p. 283.
[4] Jour. As. Soc. Bengal, Vol. XXIII, p. 92.

A report on the production of iron at this locality was written in 1873 by Dr. Warth.[1] He suggested the erection of a blast furnace and tilt hammer to improve the native methods. The proposition with reference to the blast furnace was not adopted by the Punjab Government, but a sum, not to exceed Rs. 2,000,[2] was granted to Colonel Paske to make experiments in the proposed methods of improving the outturn and economising the fuel, &c. The results are not known.

Similar ores occur at Shele to the east of Simla, and both according to Mr. Medlicott,[3] are on the same geological structure as the ores at Ramgarh in Kumaun.

Mundi State.—According to Mr. Calvert[4] there are considerable iron mines in Mundi; the ore is in the form of sand.

Kulu District.—Very little is known regarding the iron ores of this district. Mr. Calvert says that iron from neighbouring states is brought in large quantities, and sold at the annual fair in Kulu. Saucepans of beaten iron and large boilers for sugar, &c., are in considerable demand. The secret of preparing steel for swords consists, he states, in making use of charcoal from a species of euphorbia with pods of silken fibre. The plant so indicated is doubtless the *madar* (*Calatropis gigantea*), which is however not a euphorbia but an asclepiad. It may be that Mr. Calvert heard of the use of the leaves of this plant in the preparation of *wootz* in Southern India, as has been described on a previous page. The use of charcoal prepared from the roots of this plant in the manufacture of gunpowder is well known.

Sirmur State: NAHAN.—The Raja of Sirmur enjoys at the present moment the position of possessing the only iron blast-furnaces in India which are, or are about to be, put in operation. During the past year, the browing engine, which is of considerable size, was first started by the Governor General towards the end of last year. The foundry is stated to be fitted up with all modern appliances, and is under the direction of an accomplished manager. It is intended to convert the iron, and should the project be carried out, rolling-mills will, it is stated, be erected. The outturn of hot-blast pig from the new furnace is estimated to amount to 50 tons per week.

The ore to be used is stated to be magnetite, probably mixed with specular ore; it is obtained at Chaita, some 24 miles distant, by rugged roads, and for some time will have to be brought upon pack-mules. The

[1] Punjab Products, p. 8; and Mem., G. S. I., Vol. XIV, p. 284.
[2] *Vide* Indian Economist, Vol. V, p. 216.
[3] Mem., G. S. I., Vol. III, p. 178.
[4] 'Kulu,' pp. 10, 91.

fuel is charcoal from the forests, and it has also to be brought from a considerable distance, as also has the flux. These are serious impediments in the way of making the foundry a paying concern, but on the other hand, as the materials are on the Raja's land, there are some specially advantageous features in the undertaking.

Gurgaon District: Ferozpur.—The iron ores of Ferozpur and the process of smelting them were described 50 years ago by Captain Boileau,[1] and in 1878, the district officers were called upon for information regarding them in connection with the enquiries made by Government as to the distribution of iron ores in the provinces of Northern India.

The ores are probaby brown hæmatites, and they occur in rocks of the Arvali series. There is nothing to show that the deposits possess any special value, and there would certainly be a scarcity of fuel.

North-West Provinces: Kumaun.—The first and most noteworthy point in reference to the iron ores of Kumaun is the extent of the literature to which they have given rise during the past 26 years. In fact, the amount of iron which has been manufactured bears but a small proportion to the number of the reports which have been written upon the subject. Apart from the fact that access to these reports may be had by those who are specially interested, it would seem to be only adding to the incubus were it attempted to give a detailed *résumé* of the contents of these reports. It will be sufficient perhaps to state their most salient features here, and then to state briefly the ultimate conclusions as to the facilities for iron manufacture which are afforded by Kumaun; for this latter purpose, the most recent report, which is by Mr. Hughes, supplies part of the necessary information, and the remainder, which refers to the latest operations, in 1877-79, is derived from some notes kindly supplied by Mr. A. Campbell.

The existence of valuable iron ores in Kumaun was first brought to notice by Colonel Drummond in the year 1850, and a paper by Mr. J. O'B. Beckett[2] on the iron and copper ores of Kumaun, was written in the same year. He describes the native processes of manufacture, &c. In 1852 Colonel Drummond published a paper in London on the same subject.

In 1855, a well-equipped party of miners and smelters under the superintendence of Mr. W. Jory Henwood was sent out to India by the Honourable Court of Directors, to report on the iron and copper of Kumaun. The report,[3] which appeared during the course of the same year,

[1] Gleanings in Science, Vol. III, p. 327.

[2] Selections from Records, North-West Provinces Government, Vol. III, new series, p. 22.

[3] Selections from Records, Government of India, No. VIII.

was not altogether favourable to the views which had previously been expressed as to the feasibility of manufacturing iron at the foot of the hills, and somewhat strangely Burrulgaon was selected as the most suitable site for a trial blast-furnace, but it was not expected to be a commercial success, and, considering that it was situated at 60 miles distance from the plains, it is difficult to conceive how any successful result could, under any circumstances, have been expected. Mr. Henwood's object, following his instructions, was, however, to teach the natives an improved method of manufacture, and for this purpose the locality chosen was, no doubt, the most suitable.

At the same time Mr. Sowerby was sent on a roving commission by the East Indian Railway Company to enquire into the nature and extent of the iron ores, and his opinions were expressed in language of very emphatic antagonism to those of some of the previous writers.

In 1856, a report by Major, now General Sir Richard Strachey, was published on a project for the establishment of iron works in the Kumaun Bhabar. In this report, the practicability of manufacturing iron from the materials available, the probable outlay on the proposed works, and the profits to be expected from the manufacture of pig and bar iron, were fully discussed, and Dechauri was considered by General Strachey to be the most favourably situated locality for the works. The final estimate of outlay on these works was Rs. 15,75,000, and the return was calculated as follows :—

		Rs.
1,300 tons cast-iron—		
Pig iron at Rs. 50 per ton .	say .	100,000
Castings at Rs. 120 per ton .		
Average Rs. 77 per ton .		
3,500 tons of wrought bars—		
Average Rs. 140 per ton		490,000
		590,000
Deduct annual outlay		486,000
Balance giving 6½ per cent. on outlay		104,000

From Dechauri to Rurki the expense of carriage, Rs. 15 per ton, was to be added to the above prices.

Slight alterations in the data upon which the above estimate was made give very different results in either direction, but for these reference must be made to the original paper.

In 1857, the Government, with the avowed intention of demonstrating the possibility of making the manufacture of iron a success, established Mr. Sowerby, and under him a number of European assistants, at Dechauri. At the same time a company, under the title of Davies & Co.,

was permitted to commence operations. In 1858 the latter took over, at their cost price, works which had been erected at Khurpa Tal, and erected others at a cost of Rs. 1,25,000. In 1860 the Government, being dissatisfied with the expenditure and small results of the Dechauri works, appointed Dr. Oldham to report on the management, the result being that it was declared to have been both extravagant and incompetent.

The establishment was paid off, and Colonel Drummond, on behalf of a company, offered to take over the works at a valuation. In 1862 the two companies, Davies & Co. and Drummond & Co., were amalgamated under the title of the North of India Kumaun Iron Works Company (Limited). A statement of what ensued is given in a paper by Mr. E. T. Atkinson. A license was promised by Government, but there was delay in its preparation, and when ready in 1864, the company had already found that they could not make the undertaking pay and they had suspended operations, but this is said to have been in part due to difficulties about raising the necessary capital owing to the long-deferred want of title.

Another account puts the failure down, in a great measure, to want of knowledge on the part of the Directors, and the consequent absence of any definite scheme of operations; the scope of the operations expanded in a haphazard sort of way. The manager was hampered with petty details, and had to a great extent to leave the real object of the enterprise, the manufacture of iron, to others. The European mechanics were out of hand, and as the works were closed from June to October, and the men were allowed to idle during that time in the hills, it is not to be wondered that they felt hard work and discipline irksome during the remainder of the year. Their pay was assured to them whether they turned out good, bad, or no iron at all. They were well housed, but the machinery at the works was defective; the hot blast among other things was never introduced. But even the writer, from whom the above has been quoted, considers that the want of sufficient capital was the prime cause of failure.

In 1874, Mr. Bauerman visited Kumaun and reported upon the prospect of re-establishing the manufacture of iron. His opinion was not favourable either in reference to what had been done, or to the prospect of iron being made profitably in the future. This view not being acceptable to the local authorities, a further report was called for from the Geological Survey, and Mr. Hughes was deputed for the purpose. From his report,[1] the following facts as to the nature and extent of the materials are taken. The localities where ore occurs are grouped under four heads, namely, Ramgarh, Khairna, Kaladhungi, and Dechauri.

[1] Records, G. S. I., Vol. VII, p. 15.

RAMGARH.—Under this heading are included localities at Pahli, Loshgani, Natua-khan, and Parwara, which, though far apart, are on the same geological horizon. The ore is a micaceous hæmatite which occurs in beds, in association with schists. It is rich and abundant, and might be easily worked. The assays of ore from the different mines vary a good deal; at Natua-khan the ore contained 61·33 per cent. of iron. Limestone, containing only 67·6 per cent. of carbonate of lime, occurs at Natua-khan.

KHARINA.—The ore of this region is not of much promise, as it occurs as small veins of hæmatite in a bed of quartzite. If the valley of the Kosi contain rich ores they might be valuable, as they might be carried with comparative ease to the plains to mix with the poorer ores of the Bhabar; but regarding the existence of such ores there is no information.

KALADHUNGI.—The ore occurs here with the clays and sandstones of the Nahan group of tertiary rocks, but its precise mode of occurrence, in consequence of the absence of distinct sections, is not very clear.

As to its abundance there can be no doubt, but the quality is variable owing to the unequal proportions in which different portions of it are mixed with earthy matter. A favourable sample collected by Mr. Hughes contained 38·82 per cent. of iron.

DECHAURI.—The ore in this neighbourhood is of better quality, but not so extensive, as that at Kaladhungi, still there is an abundant supply.

The assays of samples from the above localities gave the following results:—

	Dechauri.	Kaladhungi.
Loss in heating	4·58	7·67
Iron oxide	70·88	49·91
Alumina	4·79	5·27
Lime	3·11	1·10
Phosphoric acid	1·67	·66
Silica and insoluble	15·81	36·62
	100·84	101·23
Metallic iron in the above	55·13	38·82

The question of fuel has been discussed over and over again in the reports alluded to above, as well as others not mentioned. The legitimate conclusion appears to be that by strict conservancy and re-planting, consumption would not exceed the available supply; but the carriage of fuel would necessarily be an expensive item if only fully-grown trees, here and there, were taken from the forests. There is not the slightest solid ground for hope that coal will ever be found, but this question has already been discussed.

The latest information in reference to this tangled history of the Kumaun iron works has been supplied by Mr. A. Campbell. It refers to

the period from 1877-79, when the Government again embarked in iron manufacture. Mr. Riley's analyses of the ores were as follows :—

	Dechauri.	Gwalakuri, average of 6.
Silica	17·92	32·42
Titanic acid	·22	...
Peroxide of iron	54·64	51·60
Protoxide of iron	tr.	7·87
Oxide of manganese	·25	1·50
Alumina	16·43	4·04
Carbonate of lime	1·99	tr.
Magnesia	·50	0·35
Phosphoric acid	·61	0·11
Sulphur	tr.	0·01
Combined water	5·65	2·53
Moisture	1·45	...
Potash	·21	...
	99·87	100·43
Metallic iron	38·25	42·36

The Dechauri ore consisted of 15 maunds, from different places, which were pounded and then sampled, so that the above may perhaps safely be taken as a fair average.

Flux.—Several of the early writers refer to the boulders of limestone found in the bed of the Boer river as being likely to yield a suitable flux, and it is believed that they were tried in the furnace during some of the operations; but in 1877-79, a tufaceous limestone was used and was found to be a much more suitable material in consequence of its comparatively small amount of magnesia, as will be seen from the following analyses by Mr. Riley :—

	Boulders from Beer river.	Mahulchaur Tufa.
Silica	·68	1·70
Alumina	·54	·74
Iron protoxide	1·12	·70
Manganese	tr.	tr.
Lime	29·45	92·20
Magnesia	21·72	4·08
Carbonic acid	46·45	...
Sulphuric acid	·18	...
Phosphoric acid	·03	Nil.
Water combined	·41	...
Moisture	·20	...
Organic matter	...	tr.
	100·78	99·42

Mr. Campbell states that there are enormous deposits of this tufaceous limestone within 7 miles radius of Dechauri.

Pig Iron.—Analyses of the pig produced from the above materials gave the following results:—

	No. 61.	No. 62.
Carbon as graphite . .	2·725	3·227
Carbon as combined carbon	1·299	·635
Silicium	1·691	1·569
Sulphur	...	...
Phosphorus	·651	·920
Iron	92·150	91·927
Manganese	1·238	1·305
Copper	...	tr.
Titanium	·171	·106
	99·925	99·689

The charge when No. 61 was produced was one-third Gwalakuri ore, two-thirds Dechauri ore, and one-third tufa limestone.

Owing to the amount of alumina present in the Dechauri ore it was found necessary to add the Gwalakuri ore, which contained sufficient silica to give a fusible cinder when added in the above proportions. But this necessity was partly instrumental in producing the collapse of the last effort to produce iron profitably in Kumaun. Great difficulty and expense was incurred in getting down the Gwalakuri to Dechauri; other causes there appear to have been too; but it is impossible without fuller information to state here exactly what they were.

As a practical record of what was accomplished, the following abstract of working for the week ending March 8th, 1879, is of value:—

Number of Charges.	Temperature of Blast.	Pressure.	Materials used in maunds.				
			Charcoal.	Dechauri ore.	Gwalakuri ore.	Tufa limestone.	Scrap iron.
273	880°	25¼	1,092	1,070¼	899¼	346	58

Outturn.

Pig No. 1.	Pig No. 2.	Pig No. 3.	Total.	Per cent. of iron from ore.	Per cent. iron to charge.	Charcoal to 1 maund of pig.
474	90	75	639	39·51	34·09	1·71

Assam.—In connection with his description of the Assam coal-fields, Mr. Mallet [1] gives a short account of the iron, from which the following facts are chiefly taken. The principal ores found in the valley of the Bhramaputra are clay ironstones from the coal-measures, and an impure limonite from the sub-Himalayan strata. The former occurs in nodules of various sizes, and sometimes in thin beds interstratified with shales and sandstones. Assays of nodules from Tirugaon and Tel Pung yielded from 40·1 to 22·1 per cent. of iron, and of the shales from Tel Pung, 23·6 per cent. The ores of the sub-Himalayan strata (Tipam group) resemble in geological position those of Kaladhungi and Dechauri in Kumaun; favourable samples yielded 35·2 and 32·6 per cent. of iron, but the average is considerably less.

Both descriptions of ores were formerly largely worked by the Assamese. According to Colonel Hannay,[2] there were 3,000 smelters and smiths in Upper Assam. The principal centres of their operations were at Tirugaon and Hattigar, where the remains of their slag heaps and furnaces are still to be seen. In the 16th and 17th centuries Assam was famous for the manufacture of big iron guns; the largest specimen known to Colonel Hannay was in the Rangpur Fort; it measured 17 feet 3½ inches and the metal was 7¾ inches thick. The final abandonment of the trade, which had suffered during incursions by the Burmese, was brought about by the heavy royalties placed on the ores by the Raja, which prevented the metal competing with that from the Khasi hills in the first place, which was not subject to duty, and afterwards with that from England, which, it is believed, supplies the whole requirements of the province at present. There is not now a single smelting furnace between Makum and Golaghat, and the trade in Khasi iron has ceased.

The ore of the coal-measures is probably not in sufficient abundance to afford a supply to a blast furnace on the English principle, while that in the sub-Himalayan rocks, though it is practically inexhaustible, is of poor quality. The scarcity of limestone in the Naga hills would prove a difficulty in the way of introducing smelting operations on a large scale.

Khasi and Jaintia Hills.—The first notice of the iron ores and system of iron manufacture in the Khasi hills, dated 1828, is by Mr. Walters,[3] who gives a sketch of the form of furnace and bellows which were in use. In 1829, Mr. Jones, in a paper in the Gleanings in Science,[4] commends

[1] Mem., G. S. I., Vol. XII, p. 359.

[2] Jour. As. Soc. Bengal, Vol. XXV, p. 330.

[3] As. Res., Vol. XVII, p.

[4] Vol. I, p. 284.

Pandua as being the most suitable place in India for the establishment of iron works, and briefly describes the native process of iron manufacture, one peculiarity he mentions being that the ore after cleaning is mixed with water, when pieces of stick, leaves, &c., are dipped into it until they take up as much as they will hold, and when dry they are thrown into the furnace. The metal was sold at Pandua for Rs. 1-4 per maund.

In 1832,[1] Mr. Cracroft described and figured the Khasi process of making iron. The bellows, of which there were two, presented some peculiarities; they were suspended vertically with the nozzles pointed downwards, and were worked alternately by a wriggling motion of the body of the operator, who balanced his weight upon them. The furnace was fed with charcoal, which had moistened iron-sand adhering to it, and the metal which formed at the bottom of the furnace was hammered out by a wooden mallet on a stone anvil. In 1834,[2] Lieutenant-Colonel T. C. Watson strongly advocated the establishment of an iron and steel factory on an extensive scale at Cherra Punji. He alludes to the abundance of coal and states that the iron ore could be obtained at the rate of four maunds for the rupee in any quantity. Fire-clay and lime are said to be abundant, while the numerous streams would afford water power for over-shot wheels.

The next paper is by Lieutenant Yule, dated 1842.[3] It is illustrated by a plate showing the method of obtaining the ore which has been reproduced in this volume (Plate VI). The principal area in which the mines were worked is situated about 18 miles north of Cherra Punji, and extends for a distance of 6 miles from east to west and of 2 miles from north to south. Mr. Yule gives a full account of the process of washing this ore, which, having been practised from time immemorial, has left its traces in what he describes as the skeletons of hills, gigantic masses of granite piled on one another in massive confusion. Dr. Oldham's description[4] of the mode of occurrence of the ore is as follows: "The only ore worked in these hills occurs in the form of a fine sand consisting of minute crystals of titaniferous magnetic oxide, which are regularly distributed in the mass of the softer portions of the granite rocks, and also occasionally in some of the gneissose beds. The upper portion of the granite is partially decomposed to a considerable depth, and this soft and easily-yielding rock is not quarried or mined, but simply raked into a small stream of water conducted along a little channel formed at the base of a small scarp or face of rock from which the ore is obtained. The

[1] Jour. As. Soc. Bengal, Vol. I, p. 150.
[2] *Op. cit.*, Vol. III, p. 25.
[3] *Op. cit.*, Vol. XI, p. 853.
[4] Mem., G. S. I., Vol. I, p. 201.

manipulative skill of some of the Khasi women, acquired by long practice in these operations, is very great, and a very small proportion of the ore is lost in the washing."

The Plate, which represents the preliminary washing in the artificial channel and the final washing in a wooden trough, will probably convey a sufficient idea of the details of the process.

The ore was sold at the rate of seven baskets, or about three maunds, for one rupee. It was conveyed often to distant villages for the rough smelting, and then the crude iron, in balls weighing seven seers each, was sold and despatched to the plains or was converted in certain of the hill villages into *kodalis* (spades) and *akows* (knives), or into hooks used by the boat-builders for fastening timbers together. In the conversion about 43 per cent. was lost owing to the impurity of the balls, which were not well hammered to express the slag, as is the case in most parts of peninsular India, but merely rudely shapen with a wooden club.

Dr. Oldham states that the quality of the iron was excellent for all such purposes as Swedish charcoal iron is used for, and that it would make good *wootz* or steel. In its ordinary condition it is less durable than English iron, which has so completely driven it out of the market in Assam, that iron manufacture, the decadence of which in the Khasi hills may be traced in the various papers above quoted, is now an extinct industry.

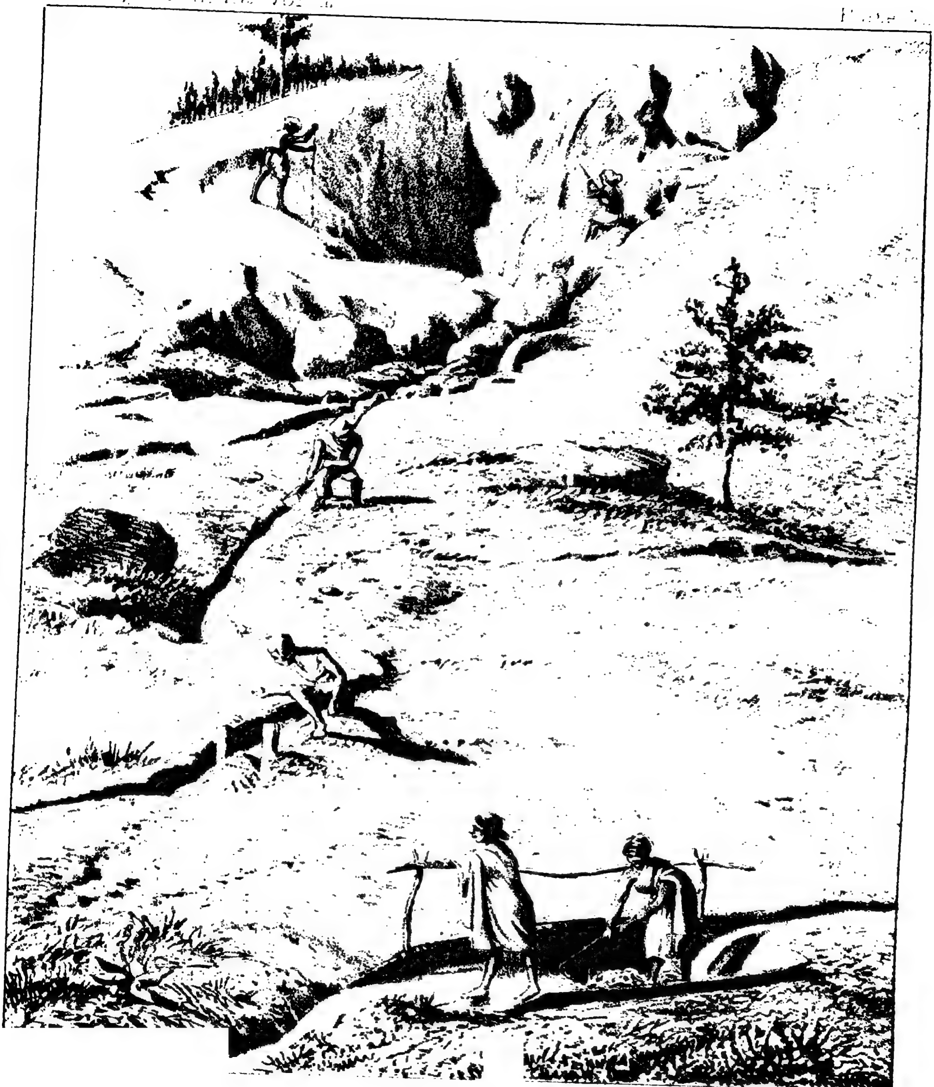
Owing to the cost of collecting the scantily disseminated ore, and the fact that it can only be practised during the rains, Dr. Oldham did not think that the manufacture of iron in the portion of the hills examined by him could be much extended.

Some additional information on this subject will be found in the Statistical Account of Assam,[1] in which, quoting from a report written by Mr. Allen in 1858, it is stated that the then annual export amounted to the value of Rs. 67,500. In 1876-77 the export of manufactured articles amounted to the value of Rs. 7,000 as against Rs. 18,000 of imported nails and bar-iron, &c.

Burma: Pegu Division.—According to Mr. Theobald,[2] an abundant source of iron ore is found in the fossil wood group (tertiary) in the Eastern Prome district. This ore consists of the hydrated peroxide, and is occasionally found as a thin band up to 3 inches in thickness, which is jointed into irregular rhomboidal masses. More frequently, however, it occurs in concretionary masses, consisting of concentric layers round a nucleus of clay, and, in this form, it occurs in both the sandstones and conglomerates.

[1] Vol. II, p. 235.

[2] Records, G. S. I., Vol. I, p. 83; Vol. VI, p. 91; and Mem., G. S. I., Vol. X, p. 343.



...ING FOR IRON SAND KHAS...

This ore is of good quality, and was largely smelted under the Burmese rule; but there are now no furnaces in operation in British territory, the introduction of English iron and steel having crushed out the industry. Remains of the furnaces, which were made in banks of firm alluvial clay, are still to be seen, and ancient slag heaps abound in the country east of the Sitang. Thick beds or lodes of magnetic ore occur in the metamorphic rocks, and specular iron occurs as an integral constituent of some of the schists and has sometimes been mistaken for galena. Mr. O'Riley states that the former is abundant in the lower hills near Shwe-gyeng.

Tenasserim Division: TAVOY, Lat. 14° 5′; Long. 98° 10′.—Dr. Helfer[1] mentions that there are 17 localities between Maulmain and Tavoy in the tertiary hills where iron ores occur; but the favourable situation of some magnetic ore, which is found at one hour's distance from the town, together with its abundance and excellent quality, gives it a far higher value than any of the others can possibly possess; not far from it is a second bed forming, apparently, a whole hill. It is probable that these ores occur in association with the tinstone-bearing granite. Samples of them were forwarded to Dr. Ure,[2] who found that they contained upwards of 60 per cent. of metallic iron with traces of phosphate of lime, but none of manganese or titanium. The magnetic properties are said to be known to the Burmese and are a cause of great wonderment to them. Dr. Helfer was unaware that this ore had ever been worked, but according to Mr. Blundell, during one of the expeditions of the Burmese against Siam, smelters were sent down from Ava, and iron was made on the spot and worked up into swords, knives, spears, and other weapons.

Limestone from Tavoy was reported on by Dr. Ure, who stated that it was perfectly pure and akin to statuary marble, and would afford a good flux. Wood for charcoal is abundant and water-carriage might be made available.

Dr. Helfer mentions that iron pyrites is abundant, and Mr. Mason that copperas or iron sulphate is often found as the result of its alteration. Red ochre occurs in several places on the Great Tenasserim.

Mergui.—An island 1 mile in circumference and including a hill 200 feet high, about 10 miles south-west of Mergui, is, according to Mr. Blundell, formed of iron ore, which Dr. Ure stated would yield good iron. Limestone is obtainable at several accessible localities on the main branches of the Tenasserim river. It is not known whether this iron has ever been worked; the process of smelting is not known to the people of Mergui.

[1] Report on Provinces of Ye, Tavoy, and Mergui, p. 29.

[2] Jour. As. Soc. Bengal, Vol. XII, p. 236.

Upper Burma.—According to Dr. Oldham, the principal site of the manufacture of iron ore of Upper Burma is at Puppa, an extinct volcano, lat. 20° 56′ 30″, long. 95° 45′, which has been described by Mr. W. T. Blanford,[1] who states that the ore occurs in upper tertiary conglomerates of the fossil wood group. He did not see the furnaces in operation, but states that their form was unlike that of any with which he was acquainted in India; and he adds that to the best of his belief they were quite peculiar in producing iron without the aid of any artificial blast whatever.

The iron, though mixed with slag and charcoal, proved when refined to be of excellent quality, and it was in this neighbourhood that a large proportion of the iron used in Upper Burma was manufactured. The *kachcha* iron, according to Dr. Oldham, was in 1855 sold at the rate of 8 to 10 tikals (£ 1 to £ 1-5) per 100 viss (=365 lbs.) according to quantity. The loss in conversion varied from 25 to 40 per cent.

The other sources of iron were at Maedoo, north of Shue-bo-myo and in the Shan States. The imported British iron was thought not to exceed 5 per cent. of the total consumption. Steel had to be brought from China or British Burma, as its manufacture was not understood.

Dr. Anderson's account[2] of the use and production of iron in the countries bordering Upper Burma, is full of interest, more especially his allusions to the use of the metal for suspension bridges.

According to Major Strover[3] the King of Burma had resolved in 1873 to utilise the ores to the west of Sagaing, near the Irawadi. Machinery for a foundry had been ordered from England, and two Engineers were already on the spot awaiting its arrival in order to commence operations. This project has apparently not been carried out.

Iron Ochre.—To the earthy varieties of the hæmatites the names red and yellow ochre are applied. Their occurrence abundantly in India is an almost necessary consequence of the abundance and wide distribution, not only of iron ores but of laterite, which, though always containing iron, is not generally called an ore of iron, except when the ferruginous matter is comparatively pure and a high percentage of iron is included. Such being the case, any attempt to convey an idea of the actual localities in India where ochre is to be found would involve an amount of detail, even were full information available, which would hardly be warranted by the importance of the subject, and for which there is not space

[1] Jour. As. Soc. Bengal, Vol. XXXI, p. 219; Manual, Part II, p. 725; and Percy's Metallurgy of Iron and Steel, p. 270, with plates.

[2] Expedition to Yunan, pp. 159, 188, 190, 311, 344, &c.

[3] Indian Economist, Vol. V, p. 14.

available. It is to be understood therefore that the following cases are representative merely, and that no attempt is made to enumerate all the localities where the natives procure these mineral pigments, which they call generically *geru*, for the adornment of the walls of houses and huts and for various other purposes.

Madras.—The decomposed ores of iron in many parts of Madras are largely used by the natives as pigments. At Trivandpuram, in Trichinopoli, a yellow ochre is obtained from the cretaceous rocks. After grinding and levigation it yields a good pigment, which is often used by Hindus to make the caste-marks on their foreheads.

Promising sources of pigment are said to be visible in road cuttings on the Nilgiris. These owe their origin to the decomposition of highly ferruginous gneiss.[1]

Bengal.—The Rajmahal[2] and Kharakpur hills afford varieties of *geru* from rocks of different ages, for which there is a small demand by the people in the neighbouring alluvial tracts; but the trade is believed to be a very small one and is probably still less so in Chutia Nagpur. Neither general statistics nor detailed information on the subject are available.

Central Provinces.—Ochreous deposits are found in several of the districts of the Central Provinces and have been worked for a long time by the natives. There is, moreover, now in the Jabalpur district a factory for the preparation of mineral paint, which has attained a wide reputation and is extensively used throughout India.

Raipur District.—Red ochre of good quality is said to be obtained in quarries at Mandanpur and Thakurtola, towards the west of this district.[3]

Balaghat District.—In the Salitikri hills, in this district, *geru* or red ochre is obtained,[4] and is used for dyeing the clothes of particular castes of people and also for colouring houses. Mr. Wilkinson[5] states that the same substance is obtained at Seukeindan, in the Laribee hills, but these names do not appear in the Central Provinces Gazetteer, and it is uncertain to what modern British district they should be referred.

Jabalpur District.—In the account of the iron ores at Jauli, it has already been mentioned that the paint prepared by Mr. W. G. Olpherts is made by grinding the ore to an impalpable powder by means of grind-stones worked by small water-wheels. The powder is packed in bags

[1] Blanford, H. F. Mem., G. S. I., Vol. IV, p. 214; and Vol. I p. 237.

[2] *Op. cit.*, Vol. XIII, p. 163.

[3] Central Provinces Administration Report, 1861-62, p. 123.

[4] Central Provinces Gazetteer, p. 18.

[5] Cal. Jour. Nat. Hist., Vol. III, p. 290.

and sells retail at the rate of £13 a ton. Its value in the London market was £9-10 a ton. It has proved to be the cheapest paint in the Indian market; it lies smoothly on wood or iron and has been successfully used against damp on porous tiles, bricks, and plaster. It is now used by the principal Rail and Steam-ship Companies, and it has stood a practical test on the metal work of the principal bridges in India; it has been found most useful on the inside of boilers.

In the preparation of one cwt. of paint, ready for use, the following components are required:—

Dry oxide of iron	65¾ lbs.
Linseed oil	5¼ gallons.

The addition to the oil of one-fourth its weight of common bazaar resin, dissolved in the oil by a gentle heat, renders the colour more brilliant and lasting. Three lbs. for a first coat and two lbs. for a second are sufficient to cover 100 superficial feet on the average.

Chanda District.—Ochreous earth is stated to be abundant in this district. In the year 1843 it sold at the rate of 15 seers for the rupee, while the red ochre above mentioned sold at the rate of 25 seers for a rupee.

Bombay Cutch.—Some highly ferruginous beds of the sub-nummulitic series yield an ochre which is quarried for export.[1]

Sikkim.—A yellow earth from Sikkim, which was forwarded by Dr. Campbell, was found by Mr. H. Piddington to be an impure ochreous earth. It was stated to be used by natives as a cure for goitre.[2]

Burma.—According to the Revd. F. Mason,[3] there is a fine bank of red ochre near Kallioung, on the Tavoy river. It is also found on the Great Tenasserim.

Iron Pyrites or Pyrite: General Remarks.—This ore of iron, which is the sulphide or sulphuret of iron, is widely distributed throughout formations of very different ages in India. It occurs in quartz reefs associated with the ores of other metals, and often with metallic gold. These quartz reefs may be either in the metamorphic or submetamorphic rocks. Iron pyrites is found in slaty rocks of different ages, and occasionally in limestones; its presence in the coal, both of the peninsular fields, and in those of tertiary, cretaceous, and jurassic ages in the extra-peninsular areas, often proves highly injurious to these coals as has already been mentioned. Spherical masses of firmly compacted cubical crystals of pyrites are found in the extra-peninsular tertiary rocks, as for instance in the

[1] Wynne, A. B. Mem., G. S. I., Vol. IX, p. 90.
[2] Jour. As. Soc. Bengal, Vol. XIX, p. 143.
[3] Natural Productions of Burma, p. 42.

nummulitic rocks of Sind; and they may in some places be collected in quantity where they have been weathered-out from the soft rocks: not unfrequently they, though retaining the form, are no longer in the condition of sulphides owing to alteration by oxidation. In the account of Sulphur (Chapter III), several localities are mentioned, where natural deposits of sulphur are formed by this process.

At Mudanur, in the Surapur taluk in the Deccan, Mr. Foote states that iron pyrites occurs in tolerable abundance in some of the Bhima limestones. He adds that, according to Colonel Meadows Taylor, the manufacture of sulphur used to be carried on there.

According to some writers, iron pyrites is abundant in several of the districts of the Madras presidency, where it is said to be called *Soornamooky*, or rather *sonmakki*, a term which is, however, properly applicable to copper pyrites. It has, however, still to be demonstrated whether it is anywhere sufficiently abundant to possess an economic importance. That supplies of iron pyrites are not easily accessible in some parts of India may be gathered from the fact that it is imported into Calcutta from Arabia, where it is obtained on the surface and in the beds of rivers.

In the Calcutta market, where it is called *kangsmookey*, the wholesale value is said to be from Rs. 6 to Rs. 10 per maund. It is used as a drug, and is prepared for that purpose by being burnt four or five times with cow-dung, after which it is ground up and administered by native practitioners as a tonic in fever.

Iron Sulphate: General Remarks.—The green vitriol or copperas of commerce, which is known to the natives as *kahi* and *hara kasis*, is produced principally from the so-called alum shales, the preparation of alum from which will be described in Chapter IX. As is the case also with alum, copperas is found sometimes as a natural exudation upon alum shales and other rocks which include iron pyrites.

This native copperas goes by several different names in India, according to the nature of the other substances with which it is combined.

Behar.—In the year 1833, Mr. J. Stevenson[1] published an analysis of a native sulphate of iron obtained from Behar, which was at that time used by the native dyers of Patna.

He found that it consisted of—

Iron sulphate	39·0
„ peroxide	36·0
Magnesia	23·0
Loss	2·0
Total	100·0

[1] Mem., G. S. I., Vol. VIII, p. 121.

Mr. Mallet [1] states that the Bijigarh shales, which belong to the Kaimur group of the Vindhyan series yield, in moist corners sheltered from the rain, a thick efflorescence of sulphate of iron, which is collected and exported to a trifling extent. The copperas works at Kasianwan, to the north of Rotas, which have been alluded to on page 256, doubtless drew their material from rocks of this age in that neighbourhood. The native alum or *salajit*, which was also obtained from these rocks, will be mentioned in the next chapter.

It may be taken generally as a fact that the distribution of iron sulphate corresponds with that of the alum-shales, so that it is needless here to give the details, which will be found in the next chapter. In various parts of the Punjab, dyes are prepared from impure mixtures of alum and iron sulphate. [2]

Iron Phosphate: General Remarks.—The hydrous iron-phosphate, otherwise called vivianite, occurs in modified oblique prisms which are dichroic, appearing green at right angles with the vertical axis and blue parallel to it. An earthy variety, called blue iron-earth, is, however, perhaps the most common form in which the mineral occurs. Traces of it are sometimes found in fossils, especially in those of the bones of vertebrates; and the so-called bone turquois or odontolite used to be made in many places by subjecting fossil bones impregnated with iron to the fire. Mr. Prinsep [3] suggested that a supply of this artificial gem may have found its way into Persia through Balkh. Under the name ελεφας ορυκτος the same substance was alluded to by Theophrastus. Vivianite is also stated to be sometimes deposited in living vegetable tissue, the result, perhaps, of a reaction taking place between iron carbonate and lime phosphate.

Under the name mineral indigo, some of this substance from Assam was described in the year 1843, [4] and for this reason it is mentioned, but as it is insoluble in water and oil, and is easily decomposed by heat, it is not likely to be of much use as a pigment. It has been observed by Mr. Medlicott [5] in Nepal in a phosphatic clay, which occurs there in some abundance and is used as a manure.

[1] Jour. As. Soc. Bengal, Vol. II, p. 321.

[2] Wynne, A. B. Mem., G. S. I., Vol. XIV, p. 302. Baden-Powell, H. Punjab Products, p. 66.

[3] Jour. As. Soc. Bengal, Vol. I, p. 362.

[4] Cal. Jour. Nat. Hist., Vol. III, p. 153.

[5] Records, G. S. I., Vol. VIII, p. 100.

CHAPTER IX.

ALUMINIUM AND CERIUM COMPOUNDS.

CORUNDUM, RUBY, SAPPHIRE, SPINEL, ALUM, CERIUM.

Corundum: General Remarks.—Corundum when pure consists simply of alumina or the sesquioxide of aluminium. Ordinarily it contains traces of lime, silica, and magnesia. In hardness it comes next to the diamond. It occurs in six-sided prisms, which are sometimes very much obscured or irregular, more commonly it is found massive or granular.

Emery, sapphire, oriental ruby, oriental topaz, oriental emerald, oriental amethyst and adamantine spar are names given to the different varieties of this mineral. The first, emery, is a granular alumina with which magnetic iron is intermixed; the others are transparent crystals, variously coloured, and are well known as gems.

The original matrix from whence these stones are derived is invariably referable to the older crystalline or metamorphic rocks, and the gem sands which are washed in the principal oriental localities where these occur are generally found to consist of the detritus of neighbouring rocks *in situ*.

Since the name corundum is derived from the Hindi word *kurand*, it is most probable that the stone first became known in Europe from having been imported From India. At all the known localities in India where corundum occurs it has been worked by the natives, and there is every reason to believe that the first discoveries date back to very early periods. Most of these localities are situated in Southern India, but a very important deposit exists in Rewah, and there are several others, regarding which less information is available, in other parts of the peninsula.

The uses to which corundum are put, when powdered, are well-known. The consumption in India must be considerable, though possibly it was

larger formerly than it is at present, as the trade of the native armourer is perhaps not so active as it used to be. A large quantity is used by the cutters and polishers of stones, both precious and ornamental, who are to be found scattered throughout India. To what extent Indian corundum is used in European countries is not very well known, but it could doubtless be applied to many of the purposes for which the emery of the Greek islands is now used, and which, owing to a monopoly at one time, reached the high price of £30 a ton in London. The emery of commerce is often much adulterated with pounded iron-slag, garnet-rock, &c.

Madras: Travancore State.—According to Dr. Balfour [1] corundum in limestone from Travancore was exhibited at the Madras exhibition. Nothing further is known as to its mode of occurrence or abundance.

Coimbatore District.—Captain Newbold [2] mentions a report that corundum had been obtained at Gudjellhutty and Chennimully in this district.

Salem District.—Captain Newbold is our principal authority regarding the occurrence of corundum in the Salem district. It is said to be found in gneiss and an earth resulting from the decomposition of that rock at Nammaul and Viralimodos, on the north bank of the Cauvery in the Permutty taluk; at Sholasigamany in the Trichingode taluk in great abundance; at Caranel, Anpore, Mallapollaye, and at various localities up the river Cauvery, as far as Coacorambadi, where it had been dug up by the natives in the fields, and the remains of the excavations were still to be traced in Newbold's time. He states, moreover, that rubies used also to be obtained at these localities, especially at Viralimodos and Sholasigamany. He adds that previously it used to be collected and sent to the western coast. Its selling price was from 50 to 100 pounds weight for a rupee. Captain Campbell [3] also gives an account of it. He says it was found in many parts of the Salem district, especially near Indore and in the Permutty taluk. Two kinds were found by the natives when ploughing their fields, one was a dirty red and the other a dark-gray colour. It was generally crystalline, but had a foliated structure and frequently included metallic looking grains. Dr. Balfour adds to the above list of localities Gopaulchettypollium, 50 miles north of Salem, Yelaneegerry and Coundapady, from all of which there were specimens in the Madras Museum.

Mysore State.—The first mention of the occurrence of corundum in Mysore appears to be by Captain Newbold, who in 1840 described the

[1] Selections from Records, Madras Government, Vol. XXXIX, p. 94.
[2] Jour. Roy. As. Soc., Vol. VII, p. 224.
[3] Cal. Jour. Nat. Hist., Vol. II, p. 281.

mines at Golhushully and Kulkairi, about 7 or 8 miles east by north from the fort of Gram.[1] In a subsequent communication he gives a further account of the same.[2]

The corundum occurs in both the crystalline and amorphous conditions in more or less decomposed talcose schists. The mines from which it was extracted were shallow pits in these rocks; it was separated by the miners into four classes, the red, white, scraps of both, and refuse. The three first were conveyed to Mangalore and Tellicherry, and were sold to Bombay and Arab merchants for from Rs. 12 to 30 per *kandy* (=500 tbs.?) according to quality. According to the natives these mines were opened about the year 1829.

Other localities where there were mines are, as stated by Newbold, Burkunhulli, Kundeo, and Yedgunkul in the Chinraipatam division; Norhik in that of Narsipur; Deysani Curbonhully in that of Bannawam; Appianhully, Beygoor, Bunnercota, Mundium and Permuty in Mysore.

Dr. Balfour mentions Nullapardy, Mundium, Cuddoor in Nuggur; Aroomully in Kankumhally taluk, and the French Rocks as localities from whence samples of corundum were in the Madras Museum.

The Mysore Gazetteer gives the following list, some of the places being obviously identical with those given above, though differently spelt: Golarhalli, near Chanraypatna; Mandya near Seringapatam; Begur, Bannerghatta, Bagepalli, &c., in the Turivekere or Tarikere taluk.

Bellary District: PUNYGHEE.—During the past year samples of corundum from the vicinity of Punyghee, in the Hindupur taluk of Bellary, were received at the Geological Survey Office from Mr. Hammiell. Mr. Mallet describes these samples as being of a sea-green colour, and having some white felspar and mica attached; the mineral is obtained from small pits, 6 or 7 feet deep, and it is stated that several thousand rupees worth have been exported to England. The local price varies from Rs. 5 to Rs. 7 per 100 seers by measure. The measure contains about 88 tolas or 2 tbs. English of grain, so that making all allowances the corundum would weigh perhaps rather more than three times as much. The price would therefore be from Rs. 5 to Rs. 7 per 600 lbs.

Mr. Hammiell states (*in epist.*) that the corundum is found in several parts of the Madaksira taluk, as well as in Hindupur.

North Arcot District.—Dr. Balfour[3] states that a specimen of clove-brown corundum of good quality, labelled as being from the Naggery hills, was included among the specimens at the Madras Museum.

[1] Madras Jour. of Lit. and Sci., Vol. XI, p. 46.

[2] Jour. Roy. As. Soc., Vol. VII, p. 219.

[3] Selections from Records, Government of Madras, No. XXXIX, p. 92.

Kistna and Godavari District.—Samples of red corundum from Guntur were exhibited at the Madras exhibition by Mr. Rohde, who considered that portions were suitable for jewellery and that the remainder were worth from £15 to £20 a ton.[1]

Hyderabad.—Dr. Walker[2] has recorded that both corundum and emery are found in the streams leading from the Kunnigiri hills, in the Kummum Circar, and also in the Paluncha country. There are two qualities, red and white, of which the last is considered to be the hardest, and is most esteemed by armourers. Dr. Balfour states that there were excellent specimens of irregularly crystalline structure forwarded from Hyderabad to the Madras exhibition.

Bengal: Monghyr District: JAMUI.—Corundum is stated to occur in the hills near Jamui,[3] and Captain Sherwill in his geological map of Bengal represents it as being found somewhat to the north-east of this locality. But there is no further information on the subject.

Central Provinces.—In the Gazetteer of the Central Provinces it is stated that a stone known to the natives as *kurund*, the common name for corundum, is found in many parts of the Upper Godavari district, especially near Bhadrachellam. In the year 1850 Dr. Macintire[4] of Nagpur forwarded to the Asiatic Society samples of corundum, some of which were said to have been quarried at a locality situated at a village named Pohora, "60 miles to the right of the Raipur road." It is presumed that south is to be understood for right, but without further information it would be useless to attempt to identify it with any locality of similar name on the map. Mr. Piddington identified the samples as consisting of white, mottled, and black corundum associated with fibrolite.

Rewah State: Singrowli: PIPRA, Lat. 23° 57′; Long. 82° 44′.—The first mention of the occurrence of corundum in Singrowli is to be found in a paper by Dr. Francis (Buchanan) Hamilton.[5] The information he obtained regarding the deposit was from enquiries made at Mirzapur in the year 1814. Although he had gone there in the hope of visiting the mine, he was prevented from doing so. The chief point of interest in the paper is the testimony which it affords of a considerable traffic being done in corundum at that period. The further details are not of much importance now, since we possess more recent and accurate information.

[1] Selections from Records, Government of Madras, No. XXXIX, p. 90.
[2] Madras Jour. of Lit and Sci., Vol. XVI, p. 187.
[3] Statistical Account of Bengal, Vol. XV, p. 31.
[4] Jour. As. Soc. Bengal, Vol. XIX, p. 489.
[5] Edin. Phil. Jour., Vol II, 1820, p. 305.

The second notice of these mines, dated 1845, is by Captain W. S. Sherwill, who also at that time had not visited the locality. He states that the mines were worked only once a year when the merchants sent pack-cattle to bring away the supply; while Dr. Hamilton mentioned the eastern parts of India as being supplied from this source, Captain Sherwill [1] states that the supply of the greater part of Western India went from here. The recognised varieties of corundum were distinguished by the following names:—

No. 1—*Gulabi*, so called from its rose colour;
No. 2—*Massuria*, resembling in colour the *massur dal*, a pea or lentil;
No. 3—*Bhaka*, of varied colours;
No. 4—*Telia*, resembling in colour the *teli* seed;
No. 5—Impure, mixed with mica;
No. 6—Very impure, mixed with fibrolite.

Captain Sherwill mentions a current belief that the rock in this mine, by permission of its guardian spirit, assumed the condition of corundum for only one day in the year; this was evidently an ingenious way of keeping up the price of the article. As a preliminary to operations a kid is sacrificed to propitiate the spirit of the mine according to Mr. Mallet.

In 1872, and again in 1873, Mr. Mallet [2] published accounts of visits to this mine which is situated on a hill between Pipra and Kadopani. The section of this hill from north to south is as follows:—

(*a.*) White quartz schist.
(*b.*) Hornblende rock passing into jade, a few yards thick.
(*c.*) White tremolitic quartz schist breaking with a fibrous fracture.
(*d.*) White and green jade, including some purple corundum and containing euphyllite and schorl. The colouring matter of the jade is clearly the same as that of the mica, oxide of chromium. *c* and *d* are about equal in thickness to *b*.
(*e.*) Bed of corundum, several yards thick. It is a reddish, sometimes purple or gray, rock almost compact and crystalline in texture and containing emerald-green euphyllite and sometimes schorl and diaspore in the seams.
(*f.*) Porphyritic gneiss with hornblende rock. The corundum does not appear to be in direct contact with the gneiss, but it is within a few feet of it, the intervening space being obscured.

The supply of corundum is considered by Mr. Mallet to be practically inexhaustible. The bed at its apparent maximum is 30 yards

[1] Jour. As. Soc. Bengal, Vol. XIV, Proc., p. 15.
[2] Records, G. S. I., Vol. V, p. 20; and Vol. VI, p. 43.

thick, but it may be more and it is traceable for about half a mile. Large blocks, two to three tons in weight, broken from the outcrop, are strewn over the hill. Before 1871, for five or six years, the mine had not been worked owing perhaps to a glut in the market, but in that year 125 bullock-loads, or 13½ tons, were taken away; the price is Rs. 2-8 for 7 maunds (of 40 seers), or 18 shillings per ton. Its excessive hardness makes it difficult to mine, but by lighting fires where it is jointed and heaving other pieces at the places where it has become brittle, the quarrymen manage to obtain fragments.

To the irregular jointing, rather than to any impurity, Mr. Mallet attributes the rather curious fact that this very hard rock does not form any prominent physical feature.

The emerald-green mica which occurs with this corundum is shown by Mr. Mallet to be almost exactly identical with euphyllite, which occurs in a similar association at Unionville in Pennsylvania.

Ajmir.—The so-called prismatic corundum found in Ajmir is merely alluded to here to prevent any mistake. It will be described, so far as there is any information on the subject, under the more appropriate heading of Beryl (Chapter XIV).

Khasi Hills: NONGRYNIEW.—A hone-stone received from the Khasi hills was found on examination by Mr. Mallet to consist of corundum. "It is a finely granular, light-gray or grayish-white rock, containing microscopically minute specks of a translucent dark-red mineral. It scratches topaz with ease. The specific gravity is 3·93.

Colonel Sherer, to whom reference was made for further information as to the locality, states that Nongryniew, where the stone is found loose on the surface, is situated two days' journey to the north-west of Nongstoin, the capital of a petty Khasi State in lat. 25° 31′, long. 91° 20′.

On this information Mr. Mallet has remarked[1] that "as the edge of the hills to the north-west of Nongstoin is about 30 miles from that place, and within 15 miles of the Bhramaputra, it would appear that the locality where the corundum is found cannot be very far from the edge of the hills, and that it is within a day or two's journey from the river for carts or laden animals. If, therefore, the stone occurs in large quantity—a point respecting which no information is available—it is worth attention commercially."

Burma.—As might be expected, pebbles and crystals of ordinary corundum are found in the ruby mines of Ava which are described below.[2]

[1] Records, G. S. I., Vol. XII, p. 172.

[2] Rev. F. Mason. Natural Productions of Burma, p. 26.

Ruby: General Remarks.—The true oriental ruby is distinguished from the different varieties of spinel-ruby by its composition, hardness, and crystalline form. In composition and hardness it is identical with corundum, being merely the clear red-coloured crystalline variety of alumina; the crystalline corundums having other colours are variously named, as has already been stated. The colour is due to the presence of metallic oxides. One per cent. of oxide of iron has been determined by analysis to occur in the ruby, together with 0·5 per cent. of lime. The ruby is only inferior in hardness to the diamond, and when of large size, of good colour, and free from flaws, it is even more valuable than the diamond.

According to Captain Newbold, as stated on a previous page, rubies used to be found in the corundum mines of the Salem district, and Dr. Clarke [1] says that coarse rubies were brought to him from the mines of Mysore. Rubies were said by Lieutenant Kittoe [2] to have been obtained in the Mahanadi river between Cuttack and Sambalpur, but it is not improbable that what were really found were garnets.

As rubies occasionally occur in Ceylon together with sapphires, the discovery of either or both in many parts of India would not be surprising. In the extra-peninsular regions, however, are situated the most famous ruby mines in the world, from which the chief part of the stones now in use have in all probability been supplied.

Upper Burma.—Although it is commonly said that no Europeans are ever allowed to visit the ruby mines of the King of Burma, there are, as a matter of fact, two descriptions by Europeans who have visited them. The first was by the Pére Guiseppe D'Amato,[3] the date of whose visit is not known, but it was before the year 1833. The other visitor was Mr. Bredmeyer, who about twelve years ago was for a time actually in charge of certain mines (not the principal) which are within 16 miles of Mandalay. He may have also been at the other mines, but that does not appear from his manuscript description.

KYAT-PYEN.—This place is situated about 70 miles to the north-east of Mandalay. It is, according to the Pére, surrounded by nine mountains which surround seventeen small lakes. The mineral district is divided into fifty or sixty parts, each having a distinct name. Mining was only carried on in the soil above water level. Square pits were dug down to a depth of 20 to 30 feet, and the detrital gem-gravel, which is obtained in beds of various thicknesses and extent, was drawn to the surface and washed; lateral galleries from these shafts were sometimes driven, but the

[1] Madras Jour. of Lit. and Sci., Vol. IX, p. 121.

[2] Jour. As. Soc. Bengal, Vol. VIII, p. 372.

[3] *Idem*, Vol. II, p. 75.

influx of water soon caused the shaft to be relinquished and a new one opened. Besides rubies, sapphires, topaz, and oriental emeralds were also found; spinel is abundant. All stones above a certain weight were supposed to become the property of the King, but some were smuggled away. Chinese and Tartar merchants were in the habit of visiting Kyatpyen yearly. Another locality where there are mines is situated a little further north at Mookop, which seems to be the same as Mogouk.

Dr. Oldham,[1] though he was prevented from visiting the mines himself, was enabled to collect some additional information when at Mandalay. He states that the rubies are generally small, not averaging more than a quarter of a *rati* in weight. The large ones are commonly flawed, and Mr. Spears had never seen a perfect one weighing more than half a rupee. Sapphires, though relatively rare, are generally of larger size—stones of 10 to 15 *ratis* without a flaw occurring—while rubies of that size are seldom seen. The revenue from the mines, which are a royal monopoly, amounts to from £12,500 to £15,000 a year. The lapidaries who polish the stones live at Amarapura; they make use of the small rubies when pounded to grind the large ones, forming the fine dust into cakes upon which they polish the gems.

The actual extent of country over which the gem sand occurs is not known, but it may be 100 square miles or more.

Sagyin Hills.—Mr. Bredemeyer states that the mines nearest to Mandalay are 16 miles from thence and 2 from the Irawadi. The mountains there are of limestone or marble covered with red clay and decayed calc-spar; they have a fractured appearance throughout, and the hollows are filled with detritus, out of which rubies, sapphires, spinels, and amethysts are obtained by washing. Where this detritus is of a yellowish colour the stones are best; with a proper system of working, which would necessitate drainage of the mines, Mr. Bredemeyer thinks these hills would yield largely.

According to Captain Strover,[2] the rubies from this locality are lighter coloured, and therefore less valuable than those in the mines further to the north.

It is evident from the above that the system of mining in practice at all the mines is very primitive; but it does not follow that much deeper mining would be requisite, as beyond the limits of the layers of gem sand, which have a capricious distribution, stones would probably not be found. A considerable number of stones, some of them being spinel, are brought to Burma for sale. The topaz being somewhat

[1] Colonel Yule's Mission to Ava in 1855, p. 347.
[2] Indian Economist, Vol. V, p. 14.

scarce is said to sell for higher prices in Burma than it would in England.

Sapphire: General Remarks.—As with the ruby so also with the sapphire, the reported cases of its discovery in peninsular India seem to be open to question. Thus one authority speaks of sapphire[1] or kyanite as though they were convertible terms, and in some cases it would seem that amethyst or blue quartz has been mistaken for sapphire. A statement[2] that sapphires have been found at the gold washings in the Upper Godavari requires confirmation.

In extra-peninsular India, in the Kulu district of the Punjab,[3] sapphires are reported to have been seen *in situ* in the rock, but no stones appear to have been ever brought from thence; this appears to have been a singular act of self-denial on the part of their discoverer. This report also certainly needs confirmation.

In Burma, sapphires, as has been above stated, occur with the rubies in the same mines. They are generally larger than the rubies, but in Mr. Spear's opinion, as quoted by Dr. Oldham, they are found in much less numbers, the proportion being as 1 to 500. In Ceylon the exact converse appears to be the rule, rubies being of rare occurrence. White sapphires, which have been mistaken for diamonds, have also been found in these Burmese mines. The oriental emerald is merely a green sapphire; it is harder than the true emerald, which is a green beryl.

Spinel or Balas Ruby: General Remarks.—The spinel ruby differs from the true oriental (corundum) ruby in composition by containing a varying percentage of magnesia, and the magnesium is occasionally replaced by iron, calcium, manganese, or zinc. The mineral therefore includes many varieties, some of which are opaque and unsuitable for jewellery. The spinel ruby is distinguished from the corundum ruby by being of inferior hardness and, when crystalline, by its octohedral form.

There is little or no information as to the occurrence of the spinel in peninsular India. Its occurrence in Mysore has been asserted, but apparently requires authentic confirmation. There are several countries beyond the confines of peninsular India where the balas ruby has been regularly mined for, and of these the following are the principal.

Afghanistan.—In the year 1879 the so-called ruby mines of the late Amir of Afghanistan, Shir Ali, which are situated near the village of Jagdalak in Kabul, were visited by Major Stewart of the Guides. Two specimens of the stones, called *yakut* by the natives, and samples of

[1] Dr. Walker. Madras Jour. of Lit. and Sci., Vol. XVI, p. 186.
[2] Central Provinces Gazetteer, p. 506.
[3] J. Calvert. Kulu, p. 54.

the matrix, were forwarded to the office of the Geological Survey for examination. The stones proved to be spinel, and the matrix a crystalline micaceous limestone. Major Stewart[1] states that the Amir kept a strict guard over the mines and only allowed particular friends of his own to work them.

Badakshan.—The balas ruby mines of Badakshan are situated on the banks of the Shighnan, a tributary of the Oxus. They have been known by reputation for very many centuries, and the name *balas* is derived from Balakshan, another form of writing the name of the country or from Balkh the capital town.[2] This may possibly be the origin of the common mistake made in English works on precious stones, namely, that these mines are situated in Balochistan! Marco Polo states that in his time the mines were wholly in the hands of the King, who kept up the value of the stones by only permitting a limited number to be exported. Colonel Yule[3] remarks upon this that the monopoly has been continued to the present day. When Murad Beg of Kunduz conquered Badakshan he was so disgusted with the poor outturn of the mines that he abandoned working them, and the population of the neighbourhood were sold as slaves. In 1866 the reigning Mir had one of the mines opened at the request of Pundit Manphul, but without much result. Wood, in 1837, attempted to visit these mines but failed; however, he gives a short account of them. The matrix, he states, is a red sandstone, or a limestone largely impregnated with magnesia; most probably it is a limestone, as such appears to be the usual matrix. The galleries were easily made and numerous, but the frequent influx of water caused much trouble.

Upper Burma.—It is stated that a large proportion of the rubies which are sold in Burma are really only spinel, this mineral apparently occurring also in the already described gem sands. When the crystalline form is obscure the two stones may be distinguished either by their hardness, specific gravity, or their refractory powers. Although of less value, the spinel rubies are largely used in jewellery.

The Rev. F. Mason,[5] who gives some interesting information on this subject, states that he had a stone, which every native who had seen it,—and some of them are very good judges indeed,—supposed to be a true oriental ruby or red sapphire, but its crystalline form—a regular octohedron—showed it to be a spinel.

He states that the dark-blue or blackish variety of spinelle called ceylanite or pleonaste is offered for sale by the Shans under the same

Prog. As. Soc. Bengal, 1880, p. 4.
Prinsep J. Jour. As. Soc. Bengal, Vol. I, p. 359.
Travels of Marco Polo, Vol. I, p. 152.
Journey to the Oxus, p. 315.
Natural Productions of Burma, p. 27.

name as sapphire. Gem sand containing small fragments of garnet, beryl, and spinel, together with the more precious stones, is a regular article of merchandise with the Shans. Three-fourths of the mass consists of spinel. Purchasers may rest assured that the valuable stones have, as a rule, been all removed by the wily Shans.

Alum: General Remarks.—The hydrous aluminum sulphate seldom occurs pure, a portion of the alumina being generally replaced by potash, soda, ammonia, magnesia, or iron, so forming a group of alums which have different compositions. As a rule these may be regarded as secondary products, since they result from the decomposition of pyrites by oxidation under the influence of heat and moisture, and the liberated sulphuric acid combines with the above-mentioned bases. Thus it is that shaly beds, containing pyrites, throw out an efflorescence of these salts when exposed to the atmosphere, and this is availed of by the native manufacturers of alum, who, as will be seen, have discovered that it is necessary to supply a second base, and therefore add nitre to the liquor. Iron sulphate may be regarded as a by-product obtained during the process.

Alum shales, so called, are of rare occurrence in peninsular India, and, so far as is known, the only considerable native manufacture is situated in Rajputana; but as will be gathered from what follows, the tertiary rocks of the extra-peninsular regions often contain such shales.

In two localities lumps of alum, the result of concentrated exudation, occur naturally in sufficient abundance to be a regular article of export.

Alum is principally used as a mordant in dyeing, but as a drug its employment is extensive in India.

Behar.—Captain Sherwill in 1846 [1] stated that a small quantity of alum was manufactured from slates obtained in the district of Shahabad; these rocks, it is believed, belonged to the Bijigarh pyritous shales of the Kaimur group of the Vindhyan series.

The alum was sold at the high price of one rupee per *tola;* it was identical with the *salajit* of Nepal, described on a following page and was highly esteemed as a drug. Copperas or iron sulphate is obtained in the same region, which is situated to the north of Rotasgarh, and to the west of the Sone (*vide* Chapter VIII).

Rajputana, Khetri, and Singhana.—In connection with the copper mines at the above localities there are manufactories which turn out considerable quantities of blue vitriol (copper sulphate), copperas (iron sulphate), and alum. The process has been very fully described and illustrated by Colonel Brooke.[2] In 1864 there were twenty of these

[1] Jour. As. Soc. Bengal, Vol. XV, p. 58.
[2] *Op. cit.*, Vol. XXXIII, p. 525.

factories at Khetri and about double the number at Singhana. The broken shale from the mine which contains the salts is placed in earthen *gharas*, together with the crust from the refuse heaps of previous lixiviations, and water is added. The *gharas* are arranged on ledges prepared for the purpose on the heaps of refuse, as will be seen by reference to Plate No. X.

Each charge of shale is exposed to three changes of water, and the water itself is changed from one *ghara* to another till it has taken up the sulphates from seven different steepings. It is then of a thick dirty-bluish colour, and is taken to the boiling-house, where it is boiled in earthen *gharas*; when sufficiently concentrated it is left to cool, and thin sticks being introduced the blue vitriol crystallizes on them. The mother liquor is then poured off and again boiled, and on the addition of saltpetre the alum crystallizes at the bottom of the vessel. The residual sulphates still in solution are allowed to crystallize out by exposing the mixture to the sun.

Seven to eight maunds of shale, with an equal quantity of the refuse, on which the exposure has caused the salts to crystallize out on the surface, yielded four seers of blue vitriol, four seers of alum, and 20 seers of mixed and impure sulphates, including copperas or iron sulphate. The selling prices per maund are for the first Rs. 14, for the second Rs. 4, and for the third Re. 1. Colonel Brooke gives an estimate of the cost of production, from which it would appear that it is not a very profitable trade. The Raja claims one-sixth of the gross produce as his royalty. Mr. Hacket[1] states that large iron vessels are sometimes used for boiling down the liquor, and records that Mr. Mallet found traces of nickel and cobalt in all these products.

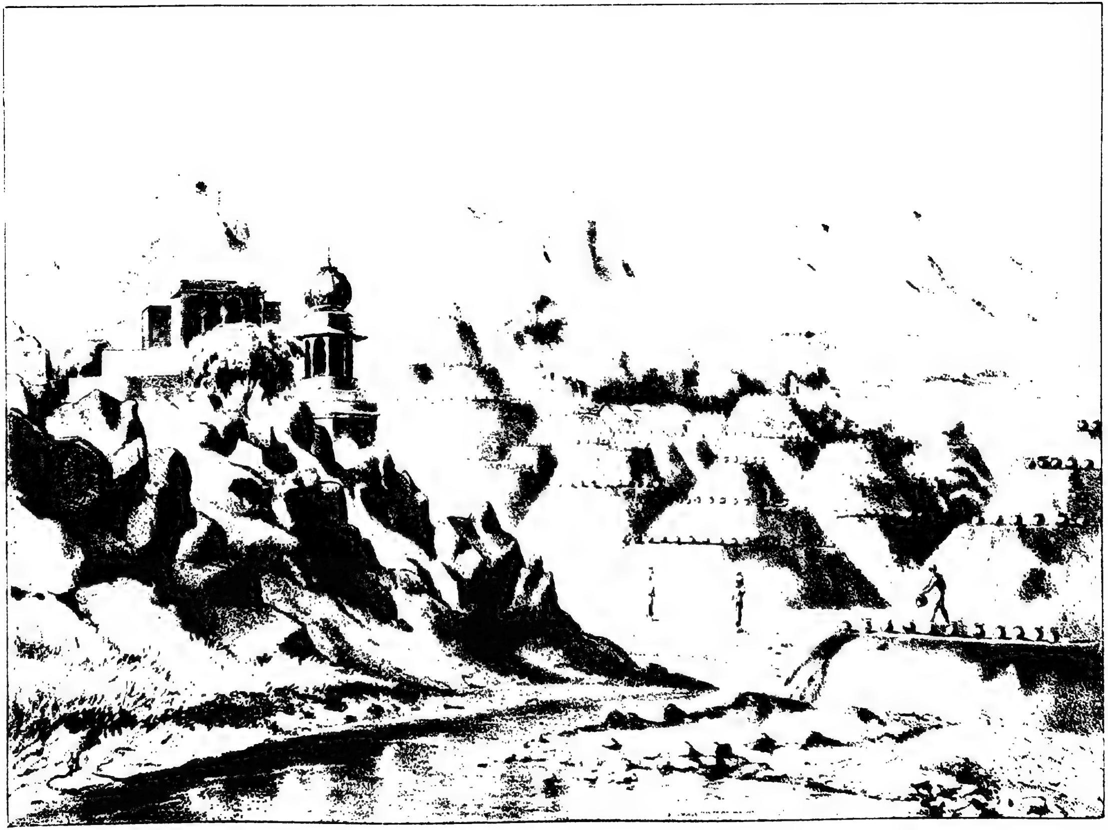
Cutch.—There are numerous accounts of the manufacture of alum in Cutch. The earliest is by Captain McMurdo, who states that before 1818 the export of alum amounted in some years to several hundred thousand maunds, which chiefly went to Guzerat and Bombay to be employed in dyeing. The following account by Mr. Wynne[2] is the most recent and complete. The site of the operations is at Mhurr or Madh.

The rock containing the materials is a pyritous dark-gray or black shale, which is in close association with a soft aluminous pseudo-breccia of the sub-nummulitic group.

This shale is excavated from pits and mines during the rains, and is exposed for four months, a slow combustion taking place owing to the decomposition of the pyrites.

"It is then spread in squares resembling salt pans and sprinkled

[1] Records, G. S. I., Vol. XIII, p. 246.
[2] Mem., G. S. I., Vol. XI, p. 88.



ALUM & SULPHATE OF COPPER WORKS KHETRI

with water. After about 12 days it consolidates into efflorescing mammillated crystalline plates or crusts called *phitkari-ka-bij*, or seed of alum. These crusts are boiled in large iron vessels (luted inside with lime), together with saltpetre (or other potash salt), in the proportion of 15 of the 'alum seed' to 6 of the latter; when it has settled the liquor is placed in small earthen vessels somewhat the shape of flower-pots, and crystallization takes place in three days. These crystals are again boiled one or more times to concentrate the solution, which is finally ladled into large thin bladder-shaped earthen *mutkas* or *gharas* with small mouths; these are sunk into the ground to prevent their breaking, and in five days the alum is found crystallized in masses. The vessels are then broken and the alum is stored."

Alum is also manufactured from the water of a hot spring north of Mhurr. The impure saltpetre, which is employed to supply the second base in the above-mentioned manner, is obtained by lixiviation of village refuse.

In the year 1867 the outturn of alum in Cutch was about 294 tons, but subsequently the demand ceased altogether. This was attributed to the State having mismanaged the monopoly, to competition in Bombay with Chinese and English alum, and to the Cutch alum being discoloured and giving a tinge of colour to cloth. According to an assay by the Chemical Examiner to Government, it would appear to be really purer than what is generally imported, containing only 13 per cent. of impurities, and yielding 10·73 per cent. of alumina, or only 0·12 per cent. less than the theoretic quantity. The State monopoly having been removed, and an improved system of working having been suggested, it is hoped that the industry may revive. Mr. Pearson has calculated that for every 560 pounds of alum 4,000 pounds of alum earth, 360 pounds of potash salts, and 240 pounds of fuel are required, and of labour, 5 men for 4½ days at a daily wage each of about one shilling.[1]

Sind.—Several accounts of Sind allude to the fact that alum is or has been manufactured by the natives, but there does not appear to be any published description of the actual process which is employed. Mr. W. T. Blanford[2] states that it is reported to consist merely in a rude lixiviation of certain pyritous shales found in the Gaj, Ranikot, and Nari groups. The potash required, it is suggested, is procured from the ashes of plants. Several places were seen where the manufacture had been carried on.

It is probable that at many places in the country on the flanks of

[1] Bombay Gazetteer, Vol. V, p. 19.
[2] Mem., G. S. I., Vol. XVII, p. 195.

the Suleman range, where so-called alum shales are known to exist, the manufacture is carried on to some extent.

Afghanistan.—According to Captain Hutton[1] the alum used in Southern Afghanistan was chiefly imported from various directions, but an inferior quality was prepared in Zamindwar.

Punjab : Bannu District : KALABAGH, Lat. 32° 58′; Long. 71° 38′ —The manufacture of alum at Kalabagh was formerly an industry of some importance. It has been described by Drs. Jameson[2] and Fleming,[3] and the following is derived from a *résumé* of their information by Mr. Wynne.[4] A layer of brushwood is spread on the ground, and upon it alternate layers, each about a foot thick, of alum shale and brushwood are placed to a height of 20 or 30 feet. The heap is ignited from below, and fresh layers are added as before. This is left burning for several months, and then the thoroughly burnt shale or *rol* is lixiviated in vats with water. The liquor is then drawn off and allowed to deposit sediment. It is subsequently boiled with an impure alkaline salt called *jamsan*, which is obtained by lixiviation from *kuller* or *reh*; which probably contains a mixture of salts of soda and potash. The liquor is then allowed to settle and slowly crystallize, the crystals being removed, washed, dried and melted in iron pans in their own water of crystallization. The fluid is then transferred into earthen ovoid jars for eight or ten days to re-crystallize; after this time the mass, which is generally hollow, is tapped, and the uncrystallized alum solution drained off, when the jars are broken and the alum is ready for sale.

The industry appears to have fallen off of late years. In 1878, when visited by Mr. Wynne, no alum was being made at Kalabagh, and at Chichali there was only one kiln at work.

Salt-range.—The manufacture of alum is, according to Mr. Wynne,[5] no longer carried on in any part of the Salt-range. Formerly it was made at Virgal, on the Son Sakesar plateau, and also beneath Sakesar mountain at the head of the Amb glen. In both these places a black shale at the base of the nummulitic limestone afforded the material.

North-West Provinces : Kumaun District.—Pyritous shales occur in different parts of Kumaun, especially near the village of Jak, on the road from Naini Tal to Khairna. There is no manufacture of alum carried on at present so far as is known, but the natural alum or *salajit* is collected for medicinal purposes.

[1] Cal. Jour. Nat. Hist., Vol. VI, p. 603.
[2] Jour. As. Soc. Bengal, Vol. XII, p. 212.
[3] *Op. cit.*, Vol. XVII, p. 522.
[4] Mem. G. S. I., Vol. XIV, p. 301; and Vol. XVII, p. 93.
[5] *Op. cit.*, Vol XIV, p. 501.

Nepal.—A more or less pure native aluminium sulphate, which is found in Nepal, is widely known as a drug under the name of *salajit*, as has been mentioned in the account of Behar. Two papers on the subject by Mr. Stevenson and Dr. Campbell respectively appeared in 1833.[1] The former gives a description of a sample which he purchased at the high rate of a rupee for two rupees weight; it was in small brownish-white lumps with a semi-crystalline structure internally. It consisted of 95 per cent. of aluminium sulphate with 3 per cent. of iron. Dr. Campbell remarked upon this that the average qualities of *salajit* contained only about 66 per. cent. of aluminum sulphate.

The mineral was found throughout the lower, central, and upper hills as an exudation upon soft rocks, and was sometimes, according to report, obtained in their substance. It was believed to be obtainable in considerable quantities, though the price at Katmandu was from Rs. 11 to Rs. 15 per maund. Sold as a drug in India, where it was used as a specific for a number of diseases, both internal and external, its price was purely fanciful. That it really occurs in Nepal anywhere in sufficient quantities to be of commercial importance is improbable, but doubtless the rocks from which it exudes might by lixiviation be made to yield a supply. Dr. Campbell alludes to a so-called black *salajit* as being probably a bituminous substance.

Assam.—Associated with the coal-measures in Upper Assam there are pyritous shales, and it has been suggested by Mr. Mallet[2] that if any considerable quantity was raised incidentally in the coal-mining, it might be profitable to use it in the manufacture of alum and copperas. Alum exudations or *salajit* are sometimes collected here too by the natives.

Burma.—Although it is not improbable that alum shales occur in several parts of Burma, it does not seem that they have hitherto attracted much notice. According to the Rev. F. Mason,[3] a clay slate in the valley of the Tenasserim, about 40 miles below Mahtah, at the forks, is a source of alum. In 1862 Dr. Brandis reported his discovery of alum shales in the Yoonzaleng district in Martaban.[4]

Turquoise: General Remarks.—The hydrous aluminum phosphate or calaite, otherwise known as turquoise, may be mentioned here, though its occurrence in India is doubtful. Mr. Prinsep[5] from the presence of certain blue streaks in the copper ores of Rajauri in Ajmir, suggested the possibility of turquoise being found there. Subsequently Dr. Irvine[6]

[1] Jour. As. Soc. Bengal, Vol II, pp. 321, 482, and 605.
[2] Mem., G. S. I., Vol XII, p. 361.
[3] Natural Productions of Burma, p. 33.
[4] Administration Report of British Burma for 1861-62, p. 39.
[5] Jour. As. Soc. Bengal, Vol. IV, p. 584.
[6] Topography of Ajmir, p. 162.

stated that it was reported to be found in the Ajmir hills and at Ramgarh in the Shekhwati country, and was used for rings, but it seems possible that this was really a variety of blue copper ore which Prinsep called a urquo ise copper ore. There has been no recent recorded discovery of turquoise in this region.

The principal known turquoise mines in the world are at Ansar, near Nishapur in Khorasan in Persia, to which Tavernier alluded under the name Michebourg.

Cerium: General Remarks.—The claims of cerium and its ores o be includedi n this account are at present very slender, their employment for any useful purpose being limited to the preparation of several medicines. The following contains the whole of the information which is available as to the distribution of ores of cerium in India.

Madras: Karnul District: GAZALPULLY—In the year 1846 Captain Newbold forwarded to the Asiatic Society a specimen of what he believed to be an ore of cerium which was obtained, as has been mentioned in Chapter VII, in the lead mine at Gazalpully. Its appearance was described as follows: [1]

"A light-reddish and fawn to peach-coloured matrix, which has sometimes a glimmering lustre like that of lepidolite, hardness about 6, but often hard enough to strike fire with steel where it appears to pass into chert, which also appears in the vein stuff. The fracture is evenly granular, inclining to splintery, streak faint pink or reddish-white, opaque." Mr. Piddington describes in detail his examination; he determined it to be a triple carbonate of iron, lime and cerium mixed with galena and traces of other substances. He was doubtful as to its having a definite composition. There does not appear to be any available information as to the abundance of this mineral.

Under the somewhat vague title, 'minéral du Coromandel,' a substance taken from India by M. Leschenault was mentioned by Beudant in his 'Traite de Mineralogie.' It has been analysed by M.M. Laugier and Damour,[2] and the latter has identified it with a mineral from the Ural mountains, which has been named Tcheffkinite, and which is a silicio-titanate of cerium, iron, lime, manganese and magnesia. It is possible that the mineral obtained by Mr. Leschenault may have been from Captain Newbold's locality.

Nepal.—An account of a mineral called nepalite has been given on page 273. According to Mr. Piddington it contained 9·4 per cent. of oxide of cerium.[3]

[1] Jour. As. Soc. Bengal, Vol. XV, p. lxii.
[2] Bull. Soc. Geol. France, 2 ser, XIX, p. 550.
[3] Jour. As. Soc. Bengal, Vol. XXIII, p. 173.

CHAPTER X.

MAGNESIUM COMPOUNDS.

EPSOMITE—MAGNESITE—TALC—STEATITE, &C.—MEERSCHAUM—SERPENTINE.

EPSOMITE—General Remarks—Punjab. MAGNESITE—General Remarks—Madras—Salem. STEATITE, &C. TALC—General Remarks—Madras—Mysore—Hyderabad—Orissa Bengal—Chutia Nagpur—Central Provinces—Berar—Rajputana—Bombay—Afghanistan—North-West Provinces—Bhutan—Burma. MEERSCHAUM—General Remarks. SERPENTITE—General Remarks—Madras—Bengal—Punjab—Burma—Andaman Islands.

Epsomite: General Remarks.—This mineral, better known as epsom salts or sulphate of magnesia, is found as an efflorescence on magnesium limestones and gypsum, and in solution in the waters of mineral springs. Its name is derived from the springs at Epsom, which were discovered more than 250 years ago and attained a considerable fame. The salts of commerce are mostly artifically manufactured either from sea-salt, from magnesian limestones, or from magnesite by treatment with sulphuric acid.

Besides the well-known medicinal uses to which epsom salts are put they are said to be sometimes used to give weight to cotton cloth, and it is therefore not improbable that the actual imports of the substance into India are more considerable than would seem from the customs returns under the heading of drugs. Doubtless epsomite is to be found as an efflorescence in many parts of India, being an occasional constituent of *reh* (see Chapter XII), but its occurrence appears to have been described only in Spiti.

Punjab: Lower Spiti.—In Lower Spiti, in connection with considerable deposits of gypsum and arragonite, Mr. Mallet[1] mentions the occurrence of a plentiful efflorescence of epsomite on the black slates which have afforded the materials from which the other minerals have been formed. By collection and lixiviation of the fragments of slate a considerable supply might easily be obtained.

Salt-range: MAYO MINES.—Under the name kieserite a hydrous magnesium sulphate has been made known as occurring mixed with sylvine (potassium chloride) in a lenticular deposit, from 2 to 3 feet thick,

[1] Mem., G. S. I., Vol. V, p. 160.

in the Mayo salt mines. Fifteen maunds of this mixture, an analysis of which will be given on a future page, was collected, but so far as is known no more has since been met with. The discovery was made by Dr. Warth.[1]

Magnesite: General Remarks.—This mineral is well known as carbonate of magnesia. It generally occurs in veins associated with other magnesian rocks, such as serpentine, dolomite, &c. Its medicinal uses, under the name magnesia, do not need to be described; when found abundantly it is used in the manufacture of Epsom salts, as has been already stated.

The principal known deposit of magnesite in India is in the Salem district of the Madras presidency. According to Lieutenant Ochterlony, it also occurs in Trichinopoli, Coimbatore, and Mysore, and according to Newbold in Nellore.

Madras: Salem District: SALEM.—The principal magnesite deposit occupies an area of about 8 or 10 square miles, which is situated 4 miles to the north-west of Salem. It is said to have been first discovered by Dr. Heyne; but in 1825 it was specially brought to the notice of the Madras Government by Dr. Macleod, who proposed its employment as cement. Some years later he was rewarded by receiving a gift of Rs. 3,000 from the Company in acknowledgment of what was then believed to be a discovery of great importance and value. There are a number of papers which describe the appearances presented by, and the characteristics of, this magnesite, but the most complete early account of it was given by Captain Newbold.[3] Subsequently, the area was examined by the Geological Survey, and Messrs. King and Foote,[4] in their report on the districts of Trichinopoli, Salem, &c., enter very fully into a description of its mode of occurrence, and they also discuss the question of its origin.

The magnesite occurs in veins which are situated in fissures traversing not only magnesian rocks, such as talcose and chloritic schists, but also, though less abundantly, certain hornblendic rocks which, where this is the case, present an altered and earthy appearance. The aspect presented by the two tracts which are included in the above-mentioned area of magnesite-traversed rocks is most peculiar, as the veins stand out in relief, and, owing to their crossings and reticulations, look like a solid

[1] Conf. Rec., G. S. I., Vol. VII, p. 64; and Mem., G. S. I., Vol. XIV, p. 80.
[2] Cal. Jour. Nat. Hist., Vol. II, p. 284.
[3] Jour. Roy. As. Soc., Vol. VII, p. 161.
[4] Mem., G. S. I., Vol. IV, p. 312.

network stretched over the surface. When freshly broken, or washed by rain, the magnesite is generally of a dazzling white colour, otherwise the colour is a subdued or dirty gray. The veins are sometimes 2 to 3 feet thick, but are generally much less. Chalcedony often occurs very intimately interspersed and coating the surface, upon which, too, crystals of quartz are sometimes to be seen. Fibrous serpentine or chrysotile is found rarely, and, as has already been stated in Chapter VIII, masses of chromite or chromic iron ore exist in sufficient abundance to have been at one time mined for. Talc is present in some parts of the deposits, but no silicate of magnesia, of the character of meerschaum, has yet been noticed, nor is there any record of jade having been obtained in connection with the hornblende or amphibole rocks, though the occurrence of either or both of these might perhaps be expected.

In the western extension of the area there is a band of potstone unaltered, and it is suggested that an impure serpentinous rock, in which a large number of the magnesite veins occur, is merely the altered condition of this potstone, the alteration having been affected by hot acidulated springs, which first dissolved a portion of the magnesia, and then deposited it in veins, as the carbonate, and with it the iron chromate, the chromic acid in which may have come from a distant source.

Messrs. King and Foote mention a number of other localities in both the Salem and Trichinopoli districts, where minor deposits of magnesite, presenting local differences, occur. For the details the reader is referred to their report. No fossils have been found in the magnesite, and the only index of age is afforded by the fact that the spring sites and the deposit generally have not been affected by marine denudation, so that the formation is subsequent in time to the period when the cretaceous rocks of Trichinopoli were upheaved. At the same time, since some of the deposits occur at a higher level than the cretaceous rocks it is conceivable that they *may* date back to an earlier time.

Talc—Steatite : General Remarks.—Talc is a magnesium silicate in which a portion of the magnesium is often replaced by iron. The so-called talc of commerce and of popular *parlance* is really mica, a wholly distinct mineral. There is no difficulty, generally speaking, in distinguishing them, for while both are flexible, mica alone is elastic. The greasy feel and pearly lustre of talc further serve to distinguish it. The foliated varieties of talc are inapplicable to the purposes to which mica is principally applied. In the form of talcose schists or potstones, and when massive in the form of steatite, soapstone, or potstone, talc is applicable to a variety of useful purposes.

Owing to the wide distribution of the varieties of talc throughout the metamorphic rocks which occupy so extended an area in India, it would be impossible, except with the expenditure of a very considerable amount of space, to give a detailed account of all that is known on the subject here. It is to be understood, therefore, that the following does not exhaust all that might be said on the subject, but that it is to be taken as representative. The references will enable those who require local information to turn to the original sources where it can be obtained.

Madras: **Salem District**: TANDAGOUNDENPOLLIAM.—A bed of compact steatite is largely worked as a potstone at this locality, and great quantities of plates, bowls, &c., are manufactured and are exported as far as Tanjore.[1] Vessels of this and similar materials are used for culinary purposes, especially by high-caste Hindus, throughout India, although they cost much more than earthenware vessels. The properties they possess, and which commend them specially for this purpose, are that they do not communicate any unpleasant taste to food as do unglazed earthenware vessels, and that they will stand great heat, so that they can not only be used for cooking but can be purified by fire, a matter of no slight importance to the class mentioned.

The manufacture of a similar potstone is also carried on at Zermaputty, a village near the end of the valley separating the Kolymullays from the Tullamullays. The vessels are, it is stated, fashioned with rude tools, and it is to be presumed finished in primitive lathes as is the custom elsewhere.

Captain Campbell[2] alludes to the common occurrence of steatite in the schistose rocks of Salem; it was used to make pencils for writing on slates; at Shoragamally, north-west of Salem, it was quarried and made into vessels of various shapes.

Mysore.—Numerous localities in Mysore, where there were potstone quarries in the early part of the century, are mentioned by Dr. Buchanan.[3] Not only was the stone used in the manufacture of vessels but as a building stone in temples and palaces. Some varieties bore the name *pratima culler*, or image stone, being chiefly used for carving into idols. According to the "Mysore and Coorg Gazetteer," the material for the famous carvings on the temple at Halebid was obtained from potstone quarries in the Hussan and Belur taluks.

The so-called blackstone of Mysore has been supposed to be a hornblendic rock, and Buchanan mentions that some of the potstone appeared

[1] W. King and R. B. Foote. Mem., G. S. I., Vol. IV, pp. 324, 371.

[2] Calc. Jour. Nat. Hist., Vol. VI, p. 213.

[3] Journey through Mysore, &c., Vols. II and III.

to him to be more nearly allied to hornblende rock. But Newbold[1] has described it as consisting of a black talcose paste with numerous crystals of magnetite. It takes a beautiful polish, and has been used for the pillars of the mausoleum of Hyder at Seringapatam. Some of these have a property of double reflection, which is regarded by the natives as evidence of supernatural agency.

In the Administration Report of Mysore for the year 1878-79, it is stated that the potstone raised during that year amounted to 920 maunds, the value being Rs. 1,000.

Hyderabad.—Dr. Heyne[2] mentions the use of steatite for writing on wooden tablets, which were prepared for the purpose by being rubbed over with the juice of green leaves. He also mentions that finely powdered talc was used to give a gloss to the surface of chunam work. Both of these, he was informed, were obtained from a place called Ananegabad.

Several of the accounts of the manufacture of iron and steel in Hyderabad mention that potstone, or as it is called by the natives *ballapam*, was used for the floor of the hearth. The refractory powers of steatite have rendered it invaluable for this very purpose in other more advanced countries too.

Orissa.—Many of the temples in Orissa, more particularly the Black Pagoda, and those at Bobaneshwar contain samples of sculptured steatite which is believed to have been obtained in the Nilgiri hills of that province, where blocks of any size may be quarried.[3]

Small idols, carved in a slaty black steatite, are sold in large numbers at Puri, and carried all over India by pilgrims as mementos of their visit to Jagannath.

Bengal: Midnapur District.—The potstones of Midnapur are, or used to be, worked at a number of localities, but the requirements of Calcutta and the alluvial districts all round are extensive, and from several parts of Chutia Nagpur and Behar the exports of stone plates, bowls, &c., are considerable.

Behar: Gya District.—A dark-blue or black steatite is obtained at a village called Pathalkati, 20 miles north-west of Gya, and is there manufactured into cups, plates, vases, figures of animals, of which, as in the case of Jagannath, large numbers are carried away by pilgrims.[4]

[1] Jour., Roy. As. Soc., Vol. XI, p. 11.

[2] Tracts, p. 272.

[3] Mem., G. S. I., Vol. I, p. 278.

[4] Statistical Account of Bengal, Vol. XIII, p. 26; Bengal Administration Report, 1876-77, p. 156.

Potstones of several qualities are obtained in different parts of this district.

Chutia Nagpur: Manbhum and Singhbhum Districts.—In the ranges of hills separating Manbhum from Singhbhum, there are a number of beds of potstone and chloritic schists, which are mined to a considerable extent, and the manufactured plates, basins, &c., are exported in some quantity *viâ* Bardwan to Calcutta, where, as also through the rest of Bengal, crockeryware is but little used by the higher classes of Hindus, who still prefer either metal or stone plates and basins for their food.

The mines in the above districts have recently been fully described.[1] The principal deposits occur as beds in the sub-metamorphic or lower transition series. There are some also in the older metamorphic rocks, and there are also some masses which occur in association with the trap from which they have been possibly derived by a process of alteration or replacement. There is considerable variety among these potstones, some being foliated, and schistose, and not very well adapted to the purpose to which they are put; others are coarsely granular or crystalline; compact or homogenous steatite in this region is rare if even it be present. Some of the varieties which include chloritic minerals, do not, when carved into vessels, stand heat; they are, accordingly, but little esteemed.

Mines, both ancient and modern, are numerous, but seldom go to greater depths than 20 or 30 feet, but horizontal galleries are occasionally driven for some distance.

Each plate or curry platter passes through four hands, the cost of production being as follows—(1) The man who quarries earns 1 anna; (2) the rough shaper; (3) the clean shaper; and (4) the turner, who uses a rude lathe in which the vessel is finished off; each earn one peiss. The employer receives from the merchants about 2½ or 3 annas; such a plate would in Calcutta sell for perhaps 8 annas.

An analysis of a fragment of one of these potstone vessels made by the late Dr. M. H. Ormsby gave:—

Silica	54·6
Alumina	5·08
Iron peroxide	6.24
Manganese dioxide	0·64
Lime	0·24
Magnesia	28·88
Water	4·00
	99·68

[1] Mem., G. S. I., Vol. XVIII, pp. 111, 148.

Central Provinces.—Talcose schists, with bands of steatite,[1] occur in the metamorphic rocks in various districts of the Central Provinces, but detailed information as to their distribution is not available. In 1843, Mr. Wilkinson stated that steatite or soapstone was largely used by the natives medicinally at Nagpur; it was sold at the rate of 10 seers for a rupee, and was supposed to be obtained in the Jabalpur district.[2] Messrs. Hislop and Hunter[3] state that a dark-coloured pot-stone, with a metallic lustre, which is found at the Jambal Ghât, in the Chanda district, was specially reserved by the Maratha authorities for the manufacture of idols. The lighter-coloured varieties which occur at Dini, near Rampaili, and at Biroli, near Tharora, on the Wainganga, have long been used for making into vessels. Steatitic schists of pure white tint, with a few included garnets, occur at Kaneri, on the Chalband river, and at various localities east of the Wainganga.

Berar : Wun District : WUN.—A steatite of fine texture and susceptible of taking a good polish, is said to occur[4] in abundance within a few miles of the town of Wun.

Rajputana : Raipur State : MORA, Lat. 26° 50′ N.; Long. 76° 51′ E.—The beautiful bluish-gray soapstone, which is so much used in Agra for the manufacture of delicately carved ornamental articles, is obtained in a mine situated 1 mile west of Mora, a village 16 miles north-west of Hindaun, in the territory of the Maharaja of Jaipur.

The following account is derived from notes made by Mr. C. H. Hacket during a recent visit (1880) to the locality. The steatite or soapstone occurs in a bed, averaging 2 feet in thickness, which is intercalated with quartzites of the Arvali series. The dip is about 30° to north-east, and the outcrop is on the side of a hill at an elevation of about 150 feet above the plain.

The quality and thickness of the material vary, and the system of mining is somewhat rude, the roofs often falling in during the rains when the mines are deserted. The entrances to the mines are by inclines which dip with the strata. Cubes of pure stone of from 1 foot to 18 inches can be obtained. The mining operations during the dry season are somewhat intermittent, as they only take place when the merchants from Agra arrive with orders, the total of which amount on the average to 1,500 maunds per annum.

The following statement of cost was obtained from the head villagers

[1] Mem., G. S. I., Vol. II, p. 137.
[2] Cal. Jour., Nat. Hist., Vol. III, p. 291.
[3] Quar. Jour., Geol. Soc., Vol. XI, part 3, p. 380.
[4] Berar Gazetteer, p. 27.

by Mr. Hacket. It will be seen that the actual miners receive less than one-tenth of what is paid by the merchants while the royalty is nearly three-tenths :—

	Per maund. As.	P.
To the Khatis or miners	1	0
Carriers from mine to Mora	2	0
Zamindar of Mora	2	0
Sonar or broker (financier)	0	6
Chowkidar of village	0	6
Chowkidar on guard	0	6
Putwari for weighing	0	6
Village charities	0	3
Maharaja of Jaipur (royalty)	3	0
Total cost delivered at Mora	10	3

Attention has recently been directed to this steatite as possibly affording a suitable substance for the manufacture of gas-burners, but whether it has been found in practice to be completely free from all tendency to deflagrate is not known.

Bombay.—In the Southern Mahratta country talcose or steatitic rocks have been extensively used in many places for manufacturing vessels and in architecture.

Ratnagiri District.—In several places potstones occur cropping out from underneath the laterite[1] of the Konkan, and are quarried, the stone being worked up into vessels. Formerly, if not still, there was a steady trade in these articles between Goa and Bombay.

Dharwar District.—Both Dr. Christie[2] and Captain Newbold[3] allude to the occurrence of potstone in the south-eastern portion of the Dharwar district, where it was manufactured into cooking vessels, and was also used in sculpture. Mr. Foote mentions that the elaborately carved stone of the famous Gadag (or Gudduck) temples in Dharwar is a chloritic rock.[4]

Afghanistan.—Steatite is known to occur in the region of the Safed Koh, and it is probably found in many other parts of Afghanistan. It is a substance less useful for the conditions of Afghan life than it is for that of the Hindus, and deposits of it would therefore be likely to be unworked in that country, for which reason might it easily escape the notice of travellers.

[1] Gibson, Dr. A. Jour. Bomb. Br. Roy. As. Soc., Vol. I, p. 144.
[2] Madras Jour. Lit. and Sci., Vol. IV, p. 462.
[3] Jour. As. Soc. Bengal, Vol. XIV, p. 291.
[4] Mem., G. S. I., Vol. XII, p. 258.

North-West Provinces: Garhwal District.—A white soapstone is found in Garhwal; being brittle it is not much used, but is turned into cups and vessels which when polished look like marble. It is said to answer the purpose of pipeclay and to be found in many places. Its exact composition does not appear to have been ascertained.[1]

Bhutan.—A pure steatite, which is believed to occur intercalated with the Buxa series near Balla has been noticed by Colonel Godwin-Austen[2] and Mr. Mallet. From loose lumps of it which are found in the Balla ravine, the Bhutanese used to manufacture cups; but the bed from whence the lumps came has not yet been found.

Burma.—Pencils made of steatite or French chalk are largely used throughout Burma for writing on blackened paper. They are principally imported from Upper Burma as square sticks sawn from the block. They are from 4 to 6 inches long and the sides about ¼ of an inch wide. An identical material is collected at numerous localities in the Arakan range by the inhabitants and applied to the same purpose. In Pegu, too, it is also obtained, but in small ovoid masses too small to yield pencils of the size of those which come from Ava.[3]

In the former case the including rocks belong to the Axial group, and in the latter to the Negrais group (*vide* Part II). In neither case does the steatite occur as an integral component of the rocks, but is due to subsequent alteration by replacement or to segregation in veins. Though often found with serpentine it also occurs independently of that rock in earthy beds. An analysis of this steatite, which is called *rangu* by the Burmese, yielded—

Water	2·4
Silica	63·11
Oxides of alumina and iron	3·41
Magnesia	30·47
Alkali	tr.
	99·39

Meerschaum.—This well-known mineral is a hydrous magnesium silicate of somewhat complicated composition; there are several closely

[1] Atkinson, E T. Economic Geology of Hill Districts, North-Western Provinces, Allahabad, 1877, p. 34.

[2] Jour. As. Soc. Bengal, Vol. XXXVII, p. 121; and Mem., G. S. I., Vol. XI, pp. 35 and 90.

[3] Theobald, W. Records, G. S. I., Vol. IV, p. 43; and Mem., G. S. I., Vol. X, pp. 336, 352.

allied minerals, and of meerschaum itself there are a few recognised varieties having different textures.

The meerschaum of commerce is obtained in Asia Minor, Greece, Moravia, Spain, &c., and when of the best quality is a valuable substance.

That a meerschaum of value occurs in any part of India is not known to be the case, and the subject is merely introduced here in order to direct attention to two localities where the prospect of finding it is perhaps sufficiently good to make it worth the while of those who may have the opportunity, to search for it.

It would be in no wise surprising if the magnesite deposits of the Salem and adjoining districts, which have been described above, were found to include meerschaum, since the deposit is in part siliceous.

It may be added that Dr. Voysey[1] parenthetically mentions a bed of meerschaum as occurring with granite to the south-west of the Tadmanur hill in Hyderabad. It is scarcely likely that this, if an original rock, was true meerschaum, but it may have occurred with magnesites; had it been of any value, it would probably have received more notice.

Among the magnesian clays and serpentines of the Nicobar Islands[2] it is conceivable that bands of meerschaum may be found if properly looked for.

Serpentine.—This mineral, otherwise called ophite, when pure, is a hydrous magnesium silicate, containing more water but less silica than talc. The proportions of these constituents respectively are—silica, 43·48; magnesia, 43·48; water, 13·04 = 100. Iron peroxide is generally present in varying proportions, and there are traces of other colouring matters which give to this mineral such varied, and often such beautiful hues. There are numerous varieties of serpentine; the so-called noble or precious serpentine is partially translucent: the fibrous, foliated, porcellanic and resin-like varieties are distinguished by various names. The fibrous varieties, which are called chrysotile, &c., resemble asbestos, but as they contain a considerable quantity of water they are not applicable to the same purposes.

Though, on account of its comparative softness, serpentine may easily be distinguished from jade, it is often mistaken for it.

Verd antique marble consists of limestone with included serpentine, which often produces a beautifully clouded stone suitable for ornamental purposes.

[1] Jour. As. Soc. Bengal, Vol. XIX, p. 201.
[2] *Conf.* Jour. As. Soc. Bengal, Vol. XXXIX, p. 27.

The distribution of serpentine rocks in India is by no means universal; in fact they may be said to be of rare occurrence, though locally they are found in some abundance.

Madras.—Serpentines, and more particularly serpentinous marbles which have, when wrought, a very ornamental appearance, are found in several localities in the Karnul and Kadapah districts. Serpentines occur in parts of Salem, especially in the region where the magnesite deposits are distributed. It may be an open question whether the black potstone of Mysore should not be properly described as a serpentine.

Bengal.—In Midnapur some of the magnesian potstones have been described as being serpentines, and they possibly do represent a transitional stage. In several parts of Chutia Nagpur true serpentines have been observed, as for instance in the districts of Manbhum and Singbhum.[1] Verd antique marble occurs in Mirzapur as will be described in the next chapter.

There appears to be no further information as to the occurrence of serpentine in peninsular India.

Punjab.—A dark-green massive serpentine, occurring in association with chloritic schists, is found in the Puga valley and in the Hanle valley below the monastery. The rock is traversed by thin seams of a finer quality which is frequently foliated; and sometimes of a yellowish-green colour. Thin seams of a white mineral, supposed to be magnesite, fill joint-cracks in this serpentine.[2] According to Mr. Calvert[3] there is a serpentine quarry on the Rangal mountain in Kulu. It is used for ornamental purposes and also medicinally for disease of the liver.

Captain Herbert mentions the occurrence of a very beautiful serpentine, which is worked beyond the Kali river in native territory.

At Shigri in Ladak there is a mine of verd antique or calcareous serpentine, which is extensively worked, the substance being incorrectly called *yessham* or jade by the inhabitants.[4] Cups made of a serpentine called *zahr muhra* are supposed to split if poison is put into them.

Burma.—Serpentine is exceedingly abundant in parts of British Burma, being found associated with the rocks of both the Axial and Negrais groups, and it accompanies the latter in their extension southwards into the Andaman and Nicobar Islands.

[1] Mem., G. S. I., Vol. XVIII, Part II.
[2] Mallet, F. R. *Op. cit.*, Vol. V, p. 172.
[3] Kulu, p. 4.
[4] Proc. As. Soc. Bengal, 1880, p. 4.

Mr. Theobald[1] states that in Pegu it occurs in three localised areas, which are all with one exception situated on the eastern side of the Arakan range, and among the outer ranges of hills. Though capable of yielding an ornamental stone on account of its colours, it is so seamed by cracks that it may be doubtful whether large pieces could be obtained.

Serpentine is also believed to occur in Tenasserim, especially in some of the islands of the Mergui archipelago.

Andaman Islands.—As already stated, serpentine occurs in the rocks of the Andaman Islands. There is an outcrop of a handsome mottled serpentine at Homfray's Ghât, not far from Port Blair, which might very probably yield a handsome stone for ornamental purposes, and in many other parts of the islands serpentines occur, with which the possibility of mercury being found has been suggested in Chapter III.

[1] Mem., G. S. I., Vol. X, p. 143; Jour. As. Soc. Bengal, Vol. XXXIX, p. 237.

CHAPTER XI.

CALCIUM, BARIUM AND STRONTIUM—COMPOUNDS.

FLUOR SPAR—General Remarks. Central Provinces—Rewah—Punjab. GYPSUM—General Remarks. Madras—Chingleput—Nellore—Bombay—Cutch—Sind—Balochistan—Afghanistan. Punjab. North-West Provinces—Burma. ANHYDRITE—General Remarks. APATITE—General Remarks. Bengal. LIMESTONE AND MARBLE, &c.—General Remarks. Madras—Trichinopoli—Coimbatore—Kadapah and Karnul. Bengal—Manbhum—Singhbhum—Hazaribagh—Lohardaga—Central Provinces—Sambalpur—Raipur—Jabalpur—Nagpur—Wardha—Vindhyan Range—Mirzapur—Central India—Gwalior. Rajputana—Alwar—Jaipur—Jodhpur—Udepur—Jesulmir—Ajmir. Bombay—Cutch—Sind—Balochistan—Afghanistan. Punjab. North-West Provinces—Kumaun and Garhwal—Darjiling—Assam. Burma—Pegu—Tenasserim—Upper Burma—Andamans KANKAR—General Remarks. CEMENT—General Remarks. BARITE—General Remarks. Madras—Karnul. Central Provinces—Jabalpur—Rewah—Punjab. CELESTINE—Bombay—Sind—Punjab.

Fluor Spar: General Remarks.—This mineral, of which the cubical crystals are well known as Derbyshire spar, consists of calcium fluoride. The uses of fluor spar are not numerous; but as it takes a high polish it is employed for making small ornamental objects: owing to its brittleness, however, it is not easy to work. In the preparation of hydrofluoric acid, with which etchings on glass and siliceous stones are made, it is employed to some extent. It is also sometimes used as a flux in the reduction of ores of copper and other metals. According to Prof Müller the murrhine cup was made of fluor spar (see, however, Chapter XIII).

The scarcity of known localities where fluor spar occurs in India is remarkable; not improbably, were there more mines of the metals worked we should meet with some supplies of the mineral, but at present the only localities where it has been found are the following:

Central Provinces: Raipur District: CHICHOLI.—Associated with the galena of this locality (see page 296), small quantities of fluor spar have been observed.[1]

Rewah State.—Fluor spar occurs thinly disseminated in the Bhanrer limestones, but as yet it has not been found in sufficient quantity to be of economic importance.[2]

Punjab: SPITI.—A light-green variety of fluor spar was obtained

[1] Records, G. S. I., Vol. I, p. 37; Vol. III, p. 44; and Vol. X, p. 185.
[2] Mem., G. S. I., Vol. VII, p. 122.

by Mr. Mallet in very small quantities in the granite dykes at the Wangtu bridge.[1]

Gypsum: General Remarks.—The hydrous calcium sulphate, or gypsum, has numerous varieties of form, and its modes of occurrence also vary; when in transparent crystals it is called selenite. In the massive form as alabaster its uses are well known; on calcination it loses its water of combination and is easily powdered; in this condition it is known as plaster of Paris. The addition of water to the powder, which has for it a strong affinity, causes it to become hard and compact, and it is this property which renders it so invaluable for taking moulds and casts, and for giving a hard finish to the surface of walls. Gypsum is largely used in some countries to lighten and enrich clayey soils.

In peninsular India gypsum rarely occurs in sufficient quantities to be of economic importance; there are, however, some sources of supply in Southern India which are availed of to a small extent. In several of the extra-peninsular regions it occurs in inexhaustible quantities, but some of these are difficult of access. A large proportion of the gypsum which is used in India is therefore imported from foreign countries, since it can be put down at the Indian ports at a price which defies competition by any of the indigenous sources of supply.

Gypsum is to be obtained in small quantities in Indian bazaars, being kept as a drug. It is supposed to have cooling properties, and a gruel made from it is administered in fevers. By the Chinese it is said to be employed for a similar purpose.

Occasionally, in India, it is burnt and used for chewing with betel instead of carbonate of lime. It is also used for whitewash and as a plaster; in one locality, Sind, it has been used for making mouldings when in the condition of plaster of Paris.

Madras: Trichinopoli District.—According to Mr. H. Blanford,[2] this mineral is abundant in many parts of the cretaceous rocks of Trichinopoli. It is generally somewhat impure, occurring in concretionary masses and in plates; it would answer when made into plaster of Paris for taking moulds, but not for casts where whiteness is required; it seldom occurs in sufficient quantity to be worth collecting, though plates of pure selenite are obtainable. It is most abundant in the Utatur beds, especially in the belemnite clays to the east of Utatur, and in the unfossiliferous clay to the north-east of Maravuttur. The reported occurrence of gypsum in Bangalore seems to require confirmation.

[1] Mem., G. S. I., Vol. V, p. 166.
[2] *Op. cit.*, Vol. IV, p. 214.

Chingleput District.—In the clayey estuarine beds to the north of Madras,[1] concretionary masses of gypsum and crystals of selenite occur, but not in any great abundance. According to Mr. Foote, supplies for making plaster of Paris for use in the School of Arts at Madras have, however, been obtained from this source.

Nellore District.—In the eastern coastal districts, of which Nellore is one, crystals of greater purity than those found near Madras are said to occur. It is considered by Mr. Foote[2] that they might be collected in the neighbourhood of the canal and forwarded to Madras, where the consumption is increasing.

Bombay.—Gypsum in the form of selenite is found in small quantities in the marine deposits about Bombay and in Kattywar, and it is stated to occur in parts of the Deccan in connection with deposits of salt. But the principal sources of gypsum in this Presidency are situated in Cutch and Sind.

Cutch.—The following is Mr. Wynne's[3] account of the distribution of gypsum in Cutch: "Large quantities of gypsum occur in shales belonging to the jurassic, sub-nummulitic and tertiary groups; the most highly gypsiferous being those of the sub-nummulitic band. The mineral is generally translucent; and clean blocks several inches in diameter may be found weathered out on the surface of the ground.

Although much of it might be obtained without greater trouble than picking up the pieces, it does not appear to be utilised except to a slight extent by goldsmiths, who are said to use it in a powdered state for polishing their wares. Among other places it occurs near a small outlying patch of tertiary rocks on the Runn east of Adeysur; near Chirtore between Adhooe and Badurgud, all in Wagir; and in the western part of the district, about 2 miles south-west of Mhurr; also east and north-east of Oomirsir and nearer Lukput."

Sind.—Several writers on the geology of Sind allude to the occurrence of gypsum. According to Mr. W. T. Blanford[4] it is found in some abundance near the top of the Gaj beds of the Kirthar range; the beds of it are not unfrequently 3 to 4 feet thick. Two such beds of different degrees of purity are exposed in the section on the banks of the Gaj river, and similar beds occur not unfrequently further to the north. Some gypsum is also found in small quantities in the rocks of the Gaj group.

[1] Mem., G. S. I., Vol. X, p. 132.
[2] *Op. cit.*, Vol. XVI, p. 104.
[3] *Op. cit.*, Vol. IX, p. 90.
[4] *Op. cit.*, Vol. XVII, p. 195.

Dr. Buist [1] has directed attention to the interesting fact that in Sind the art of making plaster of Paris was known to the natives, and that it was employed in casting lattices and open-work screens for the tops of doors, &c., where a free circulation of air was desirable; the dryness of the climate in Sind protects it from injury on exposure.

Balochistan.—It is probable that in the continuation of the Sind beds northwards into Balochistan similar beds of gypsum will be found to exist. That it actually does exist is known,[2] but details are not yet available.

Afghanistan.—Mr. Griesbach[3] states that gypsum occurs in beds, lenticular masses and veins in the Gaj formation, and that it is also found in the younger tertiary rocks, forming considerable deposits in the post-pliocene gravels and clays of the plains. Near Kandahar it is obtained from these beds. Captain Hutton has recorded that, after burning, it was largely used as a plaster in the buildings in Kandahar, and that it proved tenaceous and durable. It was first discovered in the time of Ahmed Shah, who considered it so valuable that he caused public prayers and thanksgivings to be offered up, and celebrated the event with feasting and the distribution of charity. The Pashtu name for gypsum is *gaj*.

According to Vigne[4] Ghazni is built at the foot of a long narrow ridge composed of gypsum.

Punjab : Bannu District : KALABAGH.—Gypsum is found in Kalabagh and in the Khasor range, but it is not at present utilised. Both here and also at Mari and Sardi, quartz prisms with pyramidal terminations are found in great abundance in the gypsum; they commonly go by the name of Mari diamonds.

Kohat District.—In this district gypsum is very abundant, there being, in Mr. Wynne's [5] opinion, more of it probably than there is of the rock salt with which it is associated in beds believed to be of nummulitic age. It might be obtained by open quarrying in any quantity, but it is not worked. The crops, especially the wheat, which are raised on the soil resting on an expanse of gypsum at Spina, are said to be finer than those in any other part of the country, still the natives do not appear to draw the obvious inference.

Salt-range.—In the portions of those districts which include the salt-range, gypsum occurs in enormous quantities associated with the

Trans. Bomb. Geol. Socy. (1852), Vol. X, p. 229.
Quar. Jour. Geol. Soc., Vol. II, p. 261; and Records, G. S. I., Vol. VII, p. 152.
Mem., G. S. I., Vol. XVIII, p. 59.
Cabul, p. 126.
Mem., G. S. I., Vol. XVIII, p. 93.

salt marls of silurian or pre-silurian age, and, according to Mr. Wynne,[1] smaller deposits of gypsum are also found in some of the younger groups; when powdered it is used to mix with mortar, and some of the more compact varieties near Sardi are manufactured into plates and small ornamental articles. Selenite is said to sell at Lahore for Rs. 3-14 per maund, the purpose for which it is used being probably medicinal.

Spiti.—Very considerable deposits of gypsum are found in the Spiti valley. Mr. Mallet,[2] who has described them, believes them to be derived from thermal springs, as they consist of amorphous unstratified masses, and as, moreover, there are in the vicinity thermal springs which at present deposit gypsum. The origin is traced to the ordinary chemical reaction taking place between iron pyrites and carbonate of lime, the former abounding in certain black slates. Some of this gypsum is of a beautiful snowy whiteness, and it might be employed directly for ornamental purposes, or for the manufacture of the purest plaster of Paris; one fatal bar to its use is its position, as it would have to be carried across the whole breadth of the Himalayas before it reached a market.

North-West Provinces: DEHRA.—Captain Herbert,[3] in a paper specially devoted to the subject, discusses the nature and origin of certain deposits of gypsum which occur in the Dehra Dun region. The localities were Nagal, Sahansadhara, Jari Pani, and Ranon. The including rocks were of both tertiary and older ages, and were principally limestones. Captain Herbert concluded that the gypsum of the older slaty rocks, no less than that in the younger formation, was not an original deposit. The quantity at the above-named localities was not considerable so far as had been then ascertained. Two papers by Sir Proby Cautley[4] and the Reverend Mr. Everest[5] respectively were shortly afterwards published, in which the age of these deposits was discussed in reference to the origin of the gypsum, and whether it occurred as an old bedded rock, or as an irregular mass in the rocks, the result of infiltration and the alteration of carbonate of lime; the latter, which was the view held by Captain Herbert and Sir Proby Cautley, was no doubt correct.

Many years afterwards Mr. H. B. Medlicott[6] described the gypsum of this region as occurring in lumps not unfrequently in the ferruginous clays of the Subathu group, and at Sahansadhara below Masuri in small irregular veins through limestone which is in the neighbourhood of

[1] Mem., G. S. I., Vol. XI, p. 189.
[2] *Op. cit.*, Vol. V, p. 153.
[3] As. Res., Vol. XVIII, p. 216.
[4] Jour. As. Soc. Bengal, Vol. I, p. 289.
[5] *Idem*, p. 450.
[6] Mem., G. S. I., Vol. III, p. 177.

sulphur springs. From both these sources a supply was obtained, but the demand was limited. It has been employed in the internal decoration of houses at Dehra with some success.[1]

Kumaun and Garhwal Districts.—According to Mr. E. T. Atkinson[2] gypsum is found in the Chhakhata pargana; but the most promising source is near the Nihal bridge, on the road between Kaladhungi and Naini Tal: plaster of Paris of good quality has been made from it. Gypsum is also found in Garhwal, on the banks of the Alakananda, near Panai and Nagarasu. A dark-green variety is said to be manufactured into saucers and bowls, but it may perhaps be doubted whether this is gypsum; more probably it is serpentine.

Burma: Arakan Division: RAMRI ISLAND.—At Kyauk Tyan and on Amherst island there are gypseous shales in which crystals of selenite are sparsely disseminated. The amount available is, in Mr. Mallet's[3] opinion, so small that as a source of gypsum they are practically useless. Judging from the absence of references to the occurrence of gypsum in Burma, it can only be concluded that it is scarce there, though from *a priori* considerations its occurrence in some of the tertiary rocks and the recent marine deposits might be anticipated. The Reverend F. Mason[4] speaks of a crystal of selenite from Amherst as an unusual curiosity, and he mentions that a fibrous gypsum, for sale as a cooling medicine in the shops of the Chinese, is imported from China. A granular gypsum is said, however, to be obtained on the banks of the Tenasserim river in lat. 13° 14′ north.

Anhydrite: General Remarks.—The anhydrous calcium sulphate differs from gypsum simply, so far as its composition goes, in that it contains no water of crystallization. When crystalline it may be readily distinguished by its belonging to the trimetric system, while gypsum belongs to the monoclinic. A massive variety of it which contains silica is known as vulpinite, and is sometimes cut and polished for ornamental purposes. Anhydrite occurs associated with the gypsum deposits of Spiti and in the Mayo salt mines in the Punjab.

Apatite or Calcium Phosphate: General Remarks.—This mineral generally occurs in hexagonal prisms, but it is sometimes found massive or mammilated with an internal fibrous structure; when abun-

[1] Engineers' Journal, Calcutta, Vol. V, p. 29.
[2] Economic Geology of the Hill Tracts. N. W. P., Allahabad; Pamph., p. 34.
[3] Records, G. S. I., Vol. XI, p. 222.
[4] Natural Productions of Burma, p. 31.

dant it is of great value as a manure, treatment with sulphuric acid rendering the phosphoric acid soluble. Apatite is chiefly found in the older crystalline or metamorphic rocks, but calcium phosphates are sometimes formed by the contact of guano with calcareous rocks, as for instance on coral reefs. No very large supply of this nature is likely to be found in the Indian Ocean, for although there are coral reefs and coral islands, sea-birds are not very abundant, and the monsoon rains would probably prevent such a deposit from accumulating to any great extent.

Another possible source of phosphate of lime is afforded by the fossil remains of Vertebrates; and in the search made for materials of this nature by manufacturers, the bone deposits of the Siwalik hills have not been overlooked. Not many months ago a letter of enquiry on the subject was addressed to the Government of India. Although these bones contain sometimes a considerable proportion of phosphate of lime (up to 85 per cent.[1]), others are more altered and mineralized, but what is of chief importance is that the bones are nowhere accumulated in great abundance, but are scattered here and there through considerable thicknesses of rock. There is therefore no likelihood of their collection being an object of commercial enterprise. This being so, there is, at present at least, no prospect of pounded Dinotherium and Sivatherium bones being employed in the cultivation of turnips, and palæontologists have therefore no cause for alarm.

The occurrence of apatite in crystalline rocks in India appears to have been recorded from one district only.

Bengal: Hazaribagh District.—A few stray crystals of green apatite were met with by Mr. Mallet in a granite dyke, which crosses the Tendhwa nadi south of the Mahabar hill.[2] A sample was also obtained from the Baragunda copper mines.

Marble and Limestone: General Remarks.—The following account must necessarily be somewhat imperfect, as the subject is a large one; but it is believed that no very important deposit has been overlooked. Limestones can hardly be said to be absent from any of the formations in India, though in some they are either rare or so impure as hardly to deserve the title.

In the metamorphic series, bands of crystalline limestones occur locally in some abundance, but they are capriciously distributed, being often absent over large areas. In some of the groups of the next succeeding or transition series, namely, in the Kadapah, Bijawar, and Arvali,

[1] Jour. As. Soc. Bengal, Vol. I, p. 457.

[2] Records, G. S. I., Vol. VII, p. 43.

the limestones attain a considerable development, and some of the varieties have yielded the marbles which have played such an important part in Indian architecture. In the Lower Vindhyan series the limestones are more notable for their abundance, and the wide areas over which they spread, than for producing any marbles of particular beauty. In the Upper Vindhyans limestones are principally found in the Bhanrer group, where they sometimes attain as great a thickness as 260 feet, and are used both as a building stone and for lime.

In the Gondwana series, limestones are rarely met with, and then chiefly in the Talchir and Raniganj groups, where they occur as lenticular or concretionary masses.

In the rocks of cretaceous age, within the peninsula, limestones of both sedimentary and coral reef origin occur. The other sources of lime are principally sub-recent and recent tufaceous deposits of kankar, travertin, &c.

In the extra-peninsular regions the principal formations containing limestones are of carboniferous, jurassic, cretaceous and nummulitic ages. Another source of lime, of which mention will be made on a following page, is recent coral. On the whole it may be said that although lime is a dear commodity at most of the centres of consumption, owing to the cost of carriage, possible sources of lime occur in the greatest variety throughout the country, while, on the other hand, some of the marbles are probably unsurpassed for beauty by any to be obtained in any other part of the world.

The arrangement of this work has necessitated the treatment here of calcareous rocks generally, and to save repetition no mention of them will be made in the chapter which is specially devoted to building stones.

Madras: Trichinopoli District.—In this district limestones occur both in the older crystalline or metamorphic series, and also in beds of cretaceous age. Mr. King[1] has described two beds of the former, one of which is at Naivaille, 16 miles north-west of Trichinopoli, and the other at Mootum, 4 miles further north and on the west side of the Tyaur river. The Naivaille band is 6 or 7 feet wide, and was traced for upwards of 2 miles; the dip is vertical. The limestone is of a gray colour, passing on the one hand into white, and on the other into pink. It has an obscure foliation, and between the foliæ there are bands of mica and chlorite. The Mootum band was traced for a mile, and is generally of similar character to the other, but the prevailing colour is more commonly pink. The marble when polished presented an orna-

[1] Madras Jour. of Lit. and Sci., Vol. XX, p. 272.

mental appearance, and the lime prepared from it was of excellent quality. Mr. H. Blanford[1] mentions the occurrence of a similar limestone, 2 miles to the north of Cullpolliam, on the Madras road. The stone was, he considered, too soft to withstand the solvent action of rain for any great time, and would therefore not be well adapted for outside work.

The cretaceous limestones are also soft and suffer much from exposure to rain. They are, however, largely used by the natives in the construction of temples, &c. The chief localities from which stone for these purposes is procured is the ridge at the base of the Utatur group, which extends from Purawoy to Vylapaudy. Much is obtained also from both the coral reef and sedimentary limestones at Assoor, Maravuttoor, Cullpaudy, Sirgumpoor, Varagapaudy, and other places further south. The coral reef limestone contained from 95 to 98 per cent. of carbonate of lime.[2] In other varieties the amount of calcareous matter varies considerably. As sources of lime, however, kankar and sea shells are principally employed.

Coimbatore District.—In this district a crystalline limestone, similar to that of Trichinopoli, is also found; it is soft but does not readily decompose. The prevailing colours are pink and gray. The stone is susceptible of receiving a high polish, and would be very ornamental and suitable for internal decoration. In 1857 Mr. H. Blanford[3] recommended, as the most favourable locality for working this marble, the eastern end of a ridge which crosses the Palghat road. How far this marble has been worked of late years is not known, but the outcrop being near the railway line from Madras to Bepur and Calicut, there are special facilities for carriage. Mr. King states that what has been used in connection with the railway has proved to be a satisfactory building stone.[4]

There being no source of lime on the Nilgiris the supply for buildings had to be carried up on pack-bullocks; it was burnt in kilns with fuel composed of a mixture of peat and wood.

Kadapah, Karnul and Guntur Districts.—The limestones which are found in the two series of rocks called after the two above first-named districts are employed to some extent, especially those in the Karnul series, as building stones, as for instance in the better class of houses in the villages of the Khundair valley. Some of the marbles of the Palnad are of good colours, and handsome marbles of different colours might be obtained from the breccia beds in the western scarps of Jamulmadgu,

[1] Mem., G. S. I., Vol. IV, p. 204.
[2] *Idem*, pp. 52 and 265.
[3] *Op. cit.*, Vol. I, p. 247.
[4] *Op. cit.*, Vol. IV, p. 148.

and the bottom of the slates in the Cheyair field. These are sometimes spoken of as the Guntur marbles, and polished samples of many ornamental varieties are now in the Madras Museum.

In certain tracts serpentinous marbles of great beauty occur. Although favourable reports have often been published on all these marbles, no great or steady demand for them appears to have arisen as yet.

Some of the limestones are now largely used for burning, but kankar used to be more generally employed. The adoption of the former source is mainly due to Railway and Canal Engineers.[1]

Bengal.—In the crystalline or metamorphic rocks of Western Bengal, although limestones are of somewhat rare occurrence, there are several deposits of importance, and a few, which are of minor values, owing to the rock being impure, or difficult of access. There are also a few cases in the sub-metamorphic or transition rocks; in the groups of the Gondwana series limestones are occasionally found but they are generally of limited extent. The principal ordinary sources of material for the manufacture of lime are either deposits of kankar or travertine.

Manbhum District.—In this district,[2] as has been already stated in the Chapter on Iron, there are two limestones of very different ages, one of which occurs in the crystalline rocks at Hansapathar, and the other is associated with the sandstones at the north-western corner of the Pachete hill. Analyses of both of these have been quoted on page 371. A limestone has also been found on the faulted boundary of the coal-field, about 6 miles south of Raniganj near Jamuan, and there is an outcrop of dolomitic limestone near Ramlallpur, a mile further to the south. A crystalline dolomite also occurs far to the south at the copper locality near Purda; see page 246.

Owing to these sources of lime being south of the Damuda river there would be a certain amount of expensive carriage to the nearest stations on the East Indian Railway. But, as already stated on page 372, the cost of the Pachete and Hansapathar limestones put down at the Bengal Iron Works was Rs. 4 a ton, which included charges for 10 miles carting, crossing the Damuda in boats, quarrying and royalty. It would seem that there is here an opportunity for enterprise and the saving of public money. The principal supplies of lime at present used in Calcutta either come from Sylhet or from Katni, the latter having to travel 737 miles by rail. The Hansapathar stone put down at any of the coal mines on the line might be burnt at a small cost with small coal and would then

[1] King, W. Mem., G. S. I., Vol. VIII, p. 282.
[2] *Op. cit.*, Vol. XVIII, p. 109.

only have a distance of 130 miles to travel by rail. The lime might not be quite equal to either of the present qualities in the market, but it would not be very much inferior and the supply is inexhaustible.

Singhbhum District.—Calcareous schists occur in several places in the sub-metamorphic rocks of this district; the foreign minerals occurring in them, namely, talc and actinolite or tremolite, may possibly diminish their values both as building stones and as sources of lime.[1]

Hazaribagh District.—Veins and beds of limestone have been discovered but rarely in the crystalline rocks of Hazaribagh. There is one on the road to Ramgarh, some miles south of Hazaribagh, but nothing has yet been ascertained as to its extent. It does not appear to have ever been used for burning as a source of lime, but it may yet prove of value.

A bed of crystalline limestone occurs at the Mahabagh galena mine on the Putro river (see page 291).

An analysis by Mr. Tween yielded the following results:—

Carbonate of lime	88·80
" " magnesia	3·07
Oxide of iron and alumina	·61
Insoluble	7·18
	99·66

Mr. Mallet,[2] who discovered this source of lime, has pointed out that it may be of value, but the lateral extension of the bed has not yet been ascertained; the thickness is 6 feet.

Lohardaga District.—The most considerable known deposit of limestone, in the whole of Chutia Nagpur, is found in the Tori pargana[3] in this district. Between the villages of Olherpat and Deredag the road, for a distance of 1¼ miles, crosses the vertical outcrops of a succession of calcareous gneisses, and vein-like lenticular masses of crystalline limestone of great purity. These are traceable along the strike for several miles, but their full extension has not yet been ascertained.

An apparently less pure limestone is found in the Maila river section, near Satbarwah; it is in great abundance, though not forming so extensive a deposit as the one above mentioned. As has been stated in the Chapter on Iron, these limestones may be of great value and importance, should

[1] Mem., G. S. I., Vol. XVIII. p. 88.
[2] Records, G. S. I., Vol. VII, p. 34.
[3] Mem., G. S. I., Vol. XV, pp. 32, 125.

the iron ores of the Aurunga field ever be manufactured. Their composition is as follows:—

	Olherpat.	Satbarwah.
Carbonate of lime	91·9	60·8
" magnesia	·2	16·0
Oxide of iron and alumina	·7	5·0
Insoluble	7·2	18·2
	100·0	100·0

For building purposes, and possibly also for statuary, a suitable material, perfectly white, could be obtained from the principal of these sources.

Central Provinces: Sambalpur District.—In the Lower Vindhyan rocks of the Chatisgarh basin there are at least four horizons in which limestones are found; these are particularly well seen in the cross-section from Padampur on the Mahanadi southwards. These vary from somewhat splintery white and pink limestones up to a blackish gray rock, in which there are strings of galena.

Besides the above there are several outcrops of crystalline limestones in the metamorphic rocks; the principal of these are at Kujerma to the north, and near Bolangir to the south of Sambalpur.[1]

Raipur District.—Limestone is known to be so abundant throughout the central plains of Chatisgarh that it would be difficult at present to say where it is not found, or at least easily accessible; it often has a shelly or flaky structure, and is not unfrequently impure. Some varieties, which can be easily dressed, are used as building stones; others are burnt for lime. A stone suitable for lithography has been found. All these varieties belong to the Lower Vindhyan series. It is not known whether any crystalline limestone occurs in the metamorphic rocks of Raipur.

Jabalpur District.—Not only in this district, but in others further down the valley of the Narbada, the Bijawar rocks afford limestones of various qualities, among which the famous 'marble rocks' are particularly noteworthy, both for the beauty and purity of the material of which they are composed. This is the strongest local development of the calcareous element, and, much to the disgust of lovers of the beautiful, it has been talked of as a flux by promoters of projected iron companies. Should it, however, be worked, there need be no fear that it would be necessary for a very long time to encroach upon the cliffs which confer so much beauty on the narrowed gorge of the Narbada.

[1] Records, G. S. I., Vol. X, pp. 178, 182, 183.

Except locally, in some temples, this marble has not been used for building purposes. The beds are much jointed and crushed by the disturbance, which has tilted them into their present vertical position, and by certain trap dykes which traverse them. But it seems probable that large unflawed blocks might be obtained; one which was sent to the first Paris exhibition was said to be equal to Italian marble for statuary purposes.

More valuable limestones, which belong to the Lower Vindhyan series, are extensively worked where the railway crosses the outcrop at Marwara, near the Katni station, and, as stated on a previous page, these now contribute to the supply of Calcutta, although the lime has to travel 737 miles by rail. The lime is of good quality, and is largely used by the Public Works Department at present.

Nagpur District.—In this district there are limestones belonging to two very different ages, namely, crystalline limestone, which is found in the metamorphic rocks to the north-north-east of Nagpur, near Korbadi and Mahadula, and infra-trappean or lameta limestones which are found at Kelod and Chicholi.[1] The former attracted notice many years ago; it is said to be capable of receiving a fine polish, and is extensively used for building; according to Dr. Voysey it is dolomitic. It is apparently not used as a source of lime, present requirements being supplied by kankar.

Wardha District, &c.—As regards limestone, the Wardha valley is well supplied, there being two principal sources, namely, the Vindhyan and Lameta groups, besides kankar. The occurrence of limestones in the metamorphic rocks does not appear to have been recorded. Attention has principally been directed to these limestones in reference to their suitability for employment as fluxes in connection with the reduction of the iron ores. For this purpose the Vindhyan limestones are, according to Mr. Hughes,[2] to be preferred, as they have a more reliable and constant composition than have those of the Lameta group, but samples of the latter have sometimes a composition very like the former, as may be gathered from the following analyses:—

	Vindhyan.	Lameta.
Carbonate of lime and magnesia	96·8	94·5
Oxides of iron and alumina	1·2	3·0
Phosporic acid	tr.	tr.
Insoluble	2·0	2·5
	100·0	100·0

[1] Blanford, W. T. Mem., G. S. I., Vol. IX, pp. 302, 330.

[2] *Op. cit.*, Vol. XIII, p. 172.

The most accessible outcrops of Vindhyan limestone are at Kandara, 6 miles north of Warora, and at Nilja, 8 miles west of Warora. Lameta limestone occurs at Karamgohan, 2 miles south of Warora, and in the Wardha river at Mardha, &c.

Vindhyan Range.—It will be most convenient to describe the limestones of the Vindhyan formation collectively in their extension from east to west, from the Sone to the Central Provinces. In the Lower Vindhyans, according to Mr. Mallet,[1] there is a well-defined group of thin-bedded limestones, which, where best exposed, are several hundred feet in thickness. These are quarried near Rotasgarh, on the Sone, the stone being principally used for burning; it is carried down the Sone in boats, and thence both up and down the Ganges to many distant points. The most northern of the quarries has been largely drawn upon for the supply of lime for the Sone irrigation works. At one time, when the value of the supplies nearer at hand were not fully realised, it was proposed to make use of this limestone as a flux for the iron works in the Raniganj coal-field, but the advantage of having a material with a known and steady composition only exists in so far as individual thin layers are concerned. Where principally developed in the Sone valley, the limestones are too inaccessible to be of value, but at Marwara near Kutni, as already stated, in the west, where the railway crosses the outcrop, quarries have been opened up. In Bundelkhand the Lower Vindhyan limestones are worked to a small extent for local purposes. Higher in the Vindhyan series the Bhanrer group includes a limestone which is not only used as a source of lime, but as a building stone in the Damoh district. The Jabalpur railway runs with the outcrop from Myhere westwards up the valley of the Tons. A considerable source of lime also is a tufaceous deposit which occurs about many of the falls over the Rewah and Kaimur escarpments. From it a lime of good quality is supplied to Mirzapur and Allahabad.

Mirzapur District.—Another possible source of supply in Mirzapur is afforded by certain crystalline limestones which occur in the metamorphic rocks of Mirzapur; these have also been described by Mr. Mallet.[2] The most remarkable of the bands is found in the Bichi nadi, a stream which falls into the Rehr river near Singrowli. It is in composition a typical dolomite, and is interbanded with serpentine, thus forming a very ornamental *verd antique* limestone. Slabs, from 3 to even 5 or 6 feet or more, might be obtained, showing the alternations of the two minerals. A pure white marble is crossed by the road from

[1] Mem., G. S. I., Vol. VII, p. 113.

[2] Records, G. S. I., Vol. V, p. 19; Vol. VI, p. 42.

Singrowli to Mirzapur at a point a few miles distant from the former. A white granular limestone occurs in the Oobia hill, 2 or 3 miles from the Mirzapur road, and there are other varieties at different localities.

Central India: Gwalior.—The group of transition rocks, known as the Gwalior group, contain an abundant supply of flaggy limestones suitable for building purposes, and some of them as a source of lime. But kankar is generally employed for the latter purpose.

Rajputana.—The Arvali group of transition rocks in Rajputana includes many varieties of marble, some of them being of excellent quality and great beauty. It is to be hoped that the railways may cause them to be better known and more widely employed instead of foreign marble. In order to accomplish this, reduction of freights and royalties are the first steps to be taken.

Alwar State: JHIRRI.—The quarries for white marble near Jhirri extend for a distance of 2 miles; they are not much worked at present. The stone is said to be harder to cut than the Jodhpur marble, but is more cheaply raised, being nearer the surface. The amount of stone for special purposes, which goes to Delhi annually at present, is only about 150 maunds. Formerly large monoliths were raised in these quarries; among them the pillars in the *amkhas* of the Alwar palace.

White marble is obtained also near Dadikar, 6 miles from the Alwar fort. Black marble is found near Mandla, near Ramgurh, about 16 miles east of Alwar, and a pink marble is excavated at Baldeogarh; but there is not much demand for it, though pieces large enough for images nearly life-size can be obtained.[1]

Jaipur: RAIALO OR RAIWALA.—White marble is obtained near Raialo, and it is largely employed for the filagree screens which are called *jalee*. In the opinion of Mr. Fergusson, the *jalee* work of Ahmedabad in Guzerat is still finer; but the style of the two is quite different.

According to Mr. Keene, the finest example of this form of work to be met with in Northern India is the following. He says: "But all the marble-work of this region is surpassed by the monument which Akbar erected over the remains of his friend and spiritual counsellor Shekh Sulim Chisti at Fatipur Sikri (1581 A.D.) In the north-western angle of a vast courtyard, 433 feet by 366 feet, is a pavilion externally of white marble, surrounded by a deep projecting dripstone, of white marble also, supported by marble shafts crowned by most fantastic brackets, shaped like the letter S. The outer screens are so minutely pierced that they actually look like lace at a little distance, and

[1] Gazetteer of Alwar by Major P. W. Powlett, p. 83.

illuminate the mortuary chamber within with a solemn half-light which resembles nothing else that I have seen. The whole of this elaborate work, including the strange but most pleasing design of the brackets, appears to have been produced by the resident stone-cutters of the place, uneducated men earning probably an average wage of about a penny a day. I believe that no instance of such pure patient workmanship, so dignified yet so various, is to be found in the world." [1]

Both pink and gray marbles are also obtained in the quarries at Raialo, blocks of the former containing 5 cubic feet cost from Re. 1-10 to Re. 1-14 per cubic foot; and of the latter blocks, containing 10 cubic feet, at the rate of Re. 1 to Re. 1-8 per cubic foot. There are said to be about 100 families employed in these quarries.

Jodhpur: MAKRANA.—The most extensive quarries in Rajputana appear to be situated at this locality. The marble, which is pure white, forms a long ridge running north and south; the beds are vertical, and as some of them are 2 feet thick, large blocks can be obtained.

This marble, which has been celebrated for ages, is only prevented from availing of the increased facilities of transit to Bombay and elsewhere which are now available, by the absurdly high royalty which is charged; out of a total cost of Rs. 3-8 per cubic foot, Rs. 2 is the proportion credited to the State.

The Makrana quarries supplied the marble of which the Taj at Agra is built. This glorious monument of polished white marble was erected by the Emperor Jehangir to the memory of his favourite wife, Nur Jehan. By the most competent authorities it is considered to be the most perfect and beautiful structure in the world.

From distant parts of India orders for temples are sent to Makrana, and the blocks of pure marble cut and ready to be put in place are forwarded to their destination.

Udepur: SARANGARH.—A coarse kind of marble is quarried at this locality, which is about 6 miles west of Desuri, on the western side of the Arvali range.

Jessalmir State.—A limestone, which is found in this State in the hill upon which the capital is built, is stated to be suitable for several purposes and to have yielded a material suitable for lithography.[2]

Ajmir District.—Limestones and impure marbles occur in several parts of this district; so far as is known there are no qualities which can compete with the better classes in the Native States. The quarries are not extensive, and the stone appears to be chiefly used for rough

[1] On the Stone Industries of Agra.

[2] Indian Review, Vol. III, p. 4.

building purposes and as a source of lime. Being in British territory, there are no royalties and the prices are low.

Bombay.—Although there are several allusions in the Bombay Gazetteer to limestones in several parts of the Presidency, it is not always clear what their precise nature is: the principal authentic account is by Mr. W. T. Blanford,[1] but this refers only to the western extremity of the Narbada valley. Although there is a good deal of limestone in the Bijawar series, it is too siliceous to be of much use. Crystalline limestone in the metamorphic rocks is found about Chota Udipur, and the Champanir beds include some limestones. The top bed of the Bagh group is often sufficiently pure to be used as a source of lime. In the trap area the calcareous intertrappeans do not extend to the west. At Barwai an intertrappean limestone afforded the best material available for iron smelting that could be found in that neighbourhood. At Turkesar, near Surat, nummulitic limestone is abundant.

Limestones are obtained in the Panch Mehals district at Dohad, Jambughora, and at a point about 4 miles from the Pali station. The last yields a good lime for ordinary building purposes, but it is not hydraulic[2]; some of these may be kankar. Several of the papers descriptive of the Southern Mahratta country allude to the existence of crystalline limestones. Thus Mr. Foote[3] has described grey and greenish-grey limestones which occur in some abundance 2 miles north-west and 3 miles west-south-west of Dhoni, in the Dharwar district; these would afford a beautiful building stone, and, not improbably, a good lime. Limestones also occur in some abundance in the Kaladgi and Bhima series of rocks.[4]

In Guzerat a more or less calcareous rock, for which Dr. Carter proposed the name "miliolite," has a very wide distribution. Its greatest development is in the Gir hills, where it rests upon an arenaceous clay; it is largely made up of foraminifera, and is supposed to be of pliocene age. As a building stone it is admirably suited for some purposes, but is said to be incapable of sustaining great pressure. It is largely quarried about 12 miles from Porebunder, from whence it is shipped to Bombay. It has been largely employed in the erection of many of the public buildings in Bombay.

In a very beautifully illustrated work on the Architecture of Ahmedabad, by Mr. T. C. Hope, with architectural notes by James Fergusson, photographs illustrative of *jalee* work and of buildings in sandstone will be found; many of these buildings are comparatively modern, and

[1] Mem., G. S. I., Vol. VI, p. 216.
[2] Bombay Gazetteer, Vol. III, p. 197.
[3] Records, G. S. I., Vol. VII, p. 134.
[4] Mem., G. S. I., Vol. XII, pp. 262-264.

some are quite recent. It would appear that the art of working in these materials has been more fully conserved in Guzerat than in any part of India. But it has been by no means lost or even discontinued, though it is not extensively practised now in the northern cities.

Cutch.—Limestones of different ages occur in Cutch, but the most esteemed belong to the lower jurassic group. Black or gray varieties are obtainable according to Mr. Wynne[1] from the Lodye and Jurun range, near Hubbye on the Juria hills north by west of Bhuj, and the latter at Raimulru hill near Kaora; and in several other places in the Putchum, chiefly among the Kala mountains. Another formation, consisting of broken shells, which takes a good polish, is known as Dokawana marble. Lime is usually made from a subrecent concrete or calcareous tufa, which is widely distributed.

Sind.—Limestones occur in great abundance in Sind, the bulk of the formations being made of them. According to Mr. Blanford,[2] an abundance of calcareous pebbles is found too in the pliocene and post tertiary conglomerate. Many of the above rocks are continued northwards in the Suleman and subordinate ranges which bound the Derajat.

Afghanistan: Balochistan.—Limestones of cretaceous age abound in Southern Afghanistan and also in Balochistan. Nummulitic limestones are found on the eastern frontiers of both, as well as on those of Northern Afghanistan.

In Northern Afghanistan the Safed Sang takes its name from a beautiful statuary marble.[3] In Dr. Lord's[4] account of the geology of the Hindu Kush, several varieties of limestone and marble are described. The upper part of the valley of Parwan is overhung by cliffs of limestone, in which there are numerous caves, into one of which the waters of the valley disappear for a distance of 2 miles. Some of this limestone is gray, but other portions are of dazzling whiteness. The matrix of the galena ores, &c., in the Ghorband valley is also limestone, which is again seen on the Bamian road near Jabriz and in the hills round Mardan. It affords a white marble which is quarried and it is reported to extend westwards to Herat and southwards to Kandahar. The mausoleum to Baber at Kabul was partly built of marble brought at great expense by Shah Jehan from Delhi, but was completed with stone raised in Mardan, the existence of which was not at first known in Kabul.

Punjab.—Marbles and limestones in considerable variety and from different geological formations are obtained in the Panjab and are worked

[1] Mem., G. S. I., Vol. IX, p. 90.
[2] *Op. cit.*, Vol. XVII., p. 195.
[3] Proc. As. Socy. Bengal, 1880, p. 3.
[4] Indian Review, Vol. III, p. 318.

to some extent for various purposes. At the Lahore exhibition about 20 samples from the following districts were exhibited: Hoshiarpur, Rawal Pindi, Shapur, Dera Ghazi Khan, Kohat, Jhelam, Hazara, Delhi, Hissar and Gurgaon. The Delhi marbles were probably from Rajputana.

In Mr. Wynne's reports[1] on the Salt-range of the regions both to the east and west of the Indus, and on the Kohat district, limestones suitable for building purposes are described as occurring in rocks of carboniferous triassic, jurassic and nummulitic ages respectively. Curiously enough, however, the builders of the ancient temples in the Salt-range appear to have chiefly used a calcareous travertine, even where it had to be carried from long distances. The fact that it could be easily cut when fresh, though it hardened afterwards, probably commended it to the early builders, but the material is liable to decay when in exposed situations, and being porous it would not be suitable for large modern works.

In the Punjab Himalayas the thick-bedded and hard limestones of the Krol group would yield stone fit for ornamental or monumental purposes, and a generally thin-bedded micro-crystalline magnesian limestone is found in the Blaini group (*vide* Part II, p. 599). As a source of lime, travertine or tufa is principally employed, but boulders picked out of the beds of torrents are sometimes used. Mr. H. B. Medlicott[2] has suggested that some of the limestones of the lower Krol band might yield a suitable material for the manufacture of cement.

North-West Provinces: Kumaun and Garhwal Districts.—There are several sources of limestone suitable for the manufacture of lime in these districts; the principal is afforded by the bands which occur in the Krol group (*vide* Part II, p. 601). Mr. E. T. Atkinson[3] has given a brief sketch of the distribution of the different sources of limestone and the manufacture of lime in these districts.

The best lime is obtained from the travertine in the Tarai, at the foot of the hills, and this was found to answer best as a flux in the iron works at Dechauri, as has been stated in Chapter VIII. A maund of burnt lime, delivered in any part of the district, costs 10 to 12 annas. An inferior kind of lime is also made in the Tarai from kankar.

Darjiling.—In his account of the geology of the Darjiling district and the Western Duars, Mr. Mallet[4] has entered very fully into the question of the present and possible future sources of supply of lime. Of the latter there are three, namely, the dolomite or magnesian limestone of the

[1] Mem., G. S. I., Vol. XI, p. 190; Vol. XVI, p. 298; Vol. XVII, p. 95.

[2] *Op. cit.*, Vol. III, p. 176.

[3] Economic Geology of Hill Districts of N. W. P. Allahabad, Pamph, p. 35.

[4] Mem., G. S. I., Vol. XI, p. 83.

Baxa series, the impure limestones in the tertiary rocks, and the recent calcareous tufa or travertine; the last only has been used hitherto for burning.

The dolomite forms a high range of hills just beyond the British boundary in Bhutan, but a considerable quantity of rolled masses might be obtained in the stream beds which are in British territory; east of Baxa, the same rock occurs within the British boundary. The following analysis by Mr. Tween shows that a useful lime might be manufactured from it, if for instance it was required in quantity at Jalpigori :—

	Light-gray sacharoid.	White, almost crypto-crystalline
Carbonate of lime . .	59·7	60·5
„ „ magnesia .	37·8	38·7
Oxide of iron and alumina	1·0 }	·3
Insoluble	·8 }	
	99·3	99·5

The tertiary limestones occur in thin beds and in scattered nodules and nowhere in sufficient abundance to be regularly quarried. The calcareous boulders, which are washed down in the beds of streams, vary much as to the amount of carbonate of lime which they contain. Both these facts are a drawback to the employment of this rock in the manufacture of a natural cement for which certain samples obtained in the Chicankhola river were considered by Mr. Dejoux to be well adapted. An analysis by him gave the following result :—

Carbonate of lime	68·7
„ „ magnesia	1·7
Oxide of iron and alumina	1·3
Clay	27·4
Sand	·6
Loss	·3
	100·

The calcareous tufa is found at numerous localities, but owing to an expensive and wasteful system of burning, and the cost of carriage, the lime commands a high price, being sold for Rs. 3 a maund at Pankhabari, and Rs. 2-6 at Jallapahar.

Analyses of samples from the Titi nadi gave :—

	Porous tufa.	Calcareous tufa.
Carbonate of lime	98·10	98·50
" " magnesia	1·30	1·50
Oxide of iron, alumina, and insoluble matter .	·80	·06
	100·20	100·06

Mr. Mallet suggests that limestone from the dolomite and the tufa of the Western Duars might be brought into competition with Sylhet line from Chatak over a considerable part of Lower Bengal, if not in Calcutta itself. For further information on this subject reference should be made to Mr. Mallet's memoir.

Assam.—It is not easy to give a succinct account of the sources of lime in the valley of the Bhramaputra. In some few places nummulitic limestones occur, but local deposits of travertine supply much of the lime which is used, while boulders of an old blue limestone brought down the river from above Bhramakhund are burnt for lime in some of the north-eastern districts.

The nummulitic limestones on the southern face of the Khasi and Jaintia hills afford an inexhaustible source of lime, which has been drawn upon for many years under the name of Sylhet lime, to supply the wants of Calcutta and the greater part of Lower Bengal, wherever lime made from kankar is not available. According to the Statistical Account of Assam, there are 26 quarries in the Khasi and 7 in the Jaintia hills. The principal depôts for burning are at Chatak and Sonamganj, and on the intervening portions of the bank of the Surma river.

During the year 1876-77 the estimated export was 1,600,000 maunds, valued at Rs. 480,000, and the revenue received by Government was Rs. 67,266, in addition to which the Khasi chiefs received a revenue from this source of more than Rs. 20,000. The trade is chiefly in the hands of the Messrs. Inglis, who at one time enjoyed a complete monopoly, both in limestone and the oranges for which this region is famous. The price of the lime is said to have much increased during the past twenty years, though the quantity exported has not.

Much of this nummulitic limestone would, when properly cut and polished, afford a handsomely veined marble, which would be suitable for chimney-pieces, slabs for tables, garden-seats, and for flooring-tiles.

Burma: Arakan Division.—Limestone of nummulitic age occurs in inexhaustible abundance on the island of Ramri, and several of the other

F. R. Mallet. Mem., G. S. I., Vol. XII, p. 361.

islands, and besides this rock-limestone raised coral reefs occur in several places.[1] To the south of Sandoway, at a place called Bamni, Mr. Theobald[2] states that there is an inexhaustible supply of excellent limestone, which is so situated as to be easy of access by large vessels adapted to the coasting trade. Mr. Mallet considers that both these sources of supply are worthy the notice of Calcutta, as may be judged from the following analyses :—

	Ramri.	Bamni.
Carbonate of lime	94·4	96·4
„ „ magnesia	·5	...
Iron and alumina	1·5	0·8
Insoluble	3·6	2·8
	100·0	100·0

Pegu Division.—According to Mr. Theobald nummulitic limestones abound all along the Arakan range, but to the east of the Irawadi the chief sources of lime are deposits of tufa or travertine, which are not very abundant. In Bassein at Thamandewa and Kyout-thing-bhaw on the Bassein river, there is an inexhaustible and easily accessible supply of limestone. None of the above are recommended as being suitable for ornamental purposes, but neat gray marble, suitable for flooring, is obtainable in the hills to the north-east of Toungbu.

Tenasserim Division.—True carboniferous limestones occur in this division, and the famous caves at Maulmain are in this rock. Tufaceous deposits are common; and from stalactitic limestones obtained in the caves many images and ornamental objects, which are commonly supposed to be of alabaster, are carved.[3] The limestones containing galena in the Salwin region are said to be dolomitic. A pure white marble occurs in Tavoy. A sample of it, and another from Mergui, were considered by Dr. Ure, who reported on the iron ores of Mergui, to be well adapted for employment as fluxes.[4]

Upper Burma.—The beautiful semi-transparent white marble which is so extensively used for carving into the well-known sitting and recumbent figures of Gaudama is said to be chiefly obtained from the Tsygen hills, near the village of Mowe, in the district of Madeya.

Andaman Islands.—Another alternative source of supply of lime for Calcutta is afforded by the coral reefs of the Andaman Islands. The

[1] Records, G. S. I., Vol. XI, p. 221.
[2] Mem., G. S. I., Vol. X, p. 345.
[3] Mason, Rev. F. Natural Productions of Burma, p. 29.
[4] Jour. As. Soc. Bengal, Vol. XII, p. 238.

idea has been suggested more than once during the past twenty years, and it is supposed that the only objection to it arises from the necessity for the presence of coasting vessels which would be involved, and the consequent risk of the convicts escaping; but with so pure a source of lime, abundant fuel and labour at command, there can be little doubt that Calcutta might be supplied with excellent lime at comparatively small cost, and a useful and profitable occupation would be thus afforded for the convicts.

In 1862[1] some experiments were made by the Public Works Department with lime made at Barrackpur from coral brought up as ballast from the Andamans. The cost of the lime when burnt, exclusive of freight and collection, was from Rs. 35 to 45 per 100 maunds, as against the market price of Sylhet lime from Rs. 85 to 90 per 100 maunds. Opinions differed slightly as to the relative merits of the two limes, but on the whole the coral lime was considered equal to the other; whether it would answer best to burn the lime in the Andamans and bring it up slaked like the Sylhet lime, or to burn it where fuel is more expensive, can only be determined by actual trial.

Kankar (Kunkur): General Remarks.—If the amount of space devoted in this volume to the treatment of the different subjects was in the direct ratio to the present importance of the several productions treated of, there is hardly one of them which would require a greater number of pages than kankar. But while, on the one hand, the information regarding the distribution of this deposit would be necessarily incomplete, on the other hand the repetition of details, closely like one another in reference to the different provinces and districts, would be unnecessarily tedious and not of much practical use. Under these circumstances a very brief treatment of the subject seems the only suitable alternative, and for this purpose the *résumé* of the subject given by Mr. W. T. Blanford in the first part of this work contains all that is required in order that the reader may obtain a just comprehension of the nature and mode of occurrence of this substance.

"By Anglo-Indians the term 'kankar' (which really means any kind of gravel), has been specially used for concretionary carbonate of lime usually occurring in nodules, in the alluvial deposits of the country, and especially in the older of these formations. The commonest form consists of small nodules of irregular shape, from half an inch to 3 or 4 inches in diameter, and composed within of tolerably compact carbonate of lime and externally of a mixture of carbonate of lime and clay. The more massive forms are a variety of calcareous tufa, which sometimes

[1] Engineers' Journal, Calcutta, Vol. V, p. 61.

forms thick beds in the alluvium, and frequently fills cracks in the alluvial deposits or in older rocks.

"In the beds of streams immense masses of calcareous tufa are often found, forming the matrix of a conglomerate of which the pebbles are derived from the rocks brought down by the stream. There can be no doubt that the kankar nodules, calcareous beds and veins, are all deposited from water containing in solution carbonate of lime derived either from the older rocks of various kinds, or else from fragments of limestone and calcareous formations contained in the alluvium."

The following analysis will give a fair idea of the usual composition of nodular kankar.

	1		2	3	4		5	6	7	8	9
Carbonate of lime .	72·		72·	56·94	78·5		54·	65·4	66·3	57·18	79·33
Carbonate of magnesia .	0·4		1·30	1·72	2·0						
Silica .	15·2	Oxide of iron ...	·70	1·67	2·0	Oxide of iron and alumina...	2·7	1·9	2·	10·32	6·73
Water .	1·4	Clay ..	22·	30·	10·50						
Oxide of iron and alumina .	11·0	Sand ...	2·	9·67	7·	Water and organic matter ...	2·7	2·3	[illegible]·5	...	...
						Insoluble...	40·6	30·4	27·2	32·50	13·94

As a flux for iron, kankar has been tried on several occasions, and opinions are somewhat divided as to its applicability to the purpose; but owing to the uncertainty of its composition it is distinctly less well adapted than rock limestones which have a well-defined average composition, even though in the latter the proportion of carbonate of lime may average something less.

Block kankar has been largely employed as a building-stone, more particularly in connection with the Ganges Canal works.

Cement.—Some remarks seem called for on the applicability of the above substances to the manufacture of cement as the subject is one of considerable importance and has attracted a good deal of attention of late years.

In so far as Calcutta is concerned, the question has been very fully settled. It was found that the ordinary blue clays, of which an unlimited supply can be obtained, were admirably suited for the manu-

[1] Ghazipur. Prinsep. Gleanings, in Science, Vol. III, p. 278.

[2 3 4] Raniganj. Dejoux. Records, G. S. I., Vol. VII, p. 123.

[5] Barmuri. [6] Ramnagar. [7] Sanktoria, all near Ranigang. Tween, *Ibid.*

[8 9] Saharanpur. Thomson. Rurki Treatise, Civil Engineering, Vol. I, p. 115.

facture of either Portland or ordinary artificial cement, but difficulty has been experienced in getting lime from indigenous sources of suitable quality, that is to say lime sufficiently pure and capable of being reduced easily to a fine powder. The high cost of indigenous limestones is also against their profitable employment for this purpose. As a substitute English chalk has been used with considerable success.[1] When brought out as ballast it can be laid down at a comparatively small sum. In the paper quoted below, full information on the subject of the preliminary experiments will be found. Since that time a company for the manufacture of Portland cement has been formed in Calcutta, and at present the materials used consist of an argillaceous kankar to which a fat limestone is added in the proportion necessary to bring the calcareous up to the proper relation with the argillaceous constituents. Hitherto this fat limestone has been obtained in Calcutta at a cheap rate as it is brought out as ballast.

Natural cement stones for the manufacture of both Roman and Portland cements have been used in many parts of the country. Practical information on the subject will be found in several accounts published in the Professional Papers on Indian Engineering (Rurki).

Barite or Barytes: General Remarks.—The barium sulphate occurs in modified rhombic and rectangular prisms. Its commonest mode of occurrence is in mineral lodes, where it forms a portion of the gangue.

The principal use to which it is put is to adulterate other substances of higher value. When pure and white it gives an opacity to white-lead paint, which causes it to be specially suitable for particular purposes. As a general rule, however, it is added to white-lead from fraudulent motives.

Madras: Karnul District.—The principal gangue stone in the Gazalpully or Baswapur lead mine (*vide* page 284) consists of Barytes, and if required it seems possible that a large supply could be obtained there.

Central Provinces: Jabalpur District: SLEEMANABAD.—Barytes occurs in association with the traces of copper ores (*vide* Chapter V), at this locality.

Rewah State: SOHAGI GHAT, Lat. 24°; Long. 81° 45′.—Small quantities of barytes have been obtained in the lower Rewah beds at this locality, and also in the Ginga hill.[2]

[1] Supplement, *Gazette of India*, January 16, 1875, p. 88.
[2] Mem., G. S. I., Vol. VII, p. 122.

Rajputana: Ajmir District: TARAGARH.—Barytes is said to occur in the lead mines at this locality [1] (*vide* page 299).

Punjab: Simla District: SUBATHU.—Barytes is found associated with galena in the lead mines at this locality (*vide* page 304).

Celestite or Celestine: General Remarks.—Strontium sulphate or celestine occurs in rhombic or tabular crystals of the trimetric system, and is also found massive. Its chief use in the Arts is for making the strontium nitrate, which is an ingredient in fireworks, where a red fire is required. There are at present only two known localities in India where this mineral occurs.

Bombay: Sind: KOHISTAN.—Crystalline lumps of celestine, which were about the size of walnuts, were found somewhat sparingly by Mr. Fedden scattered "over the surface of the Kirthar limestones, especially to the east of the range which lies eastward of Bhule Khan's thana." [2]

Punjab: Salt Range: SURDAG.—Celestine has been found by Mr. Wynne in red clays of tertiary age at the above locality. It is not supposed to be abundant there.

[1] Dr. Irvine. Topography of Ajmir, p. 166.

[2] Mem., G. S. I., Vol. XVII, p. 196.

CHAPTER XII.

SODIUM AND POTASSIUM COMPOUNDS.

SALT (SODIUM CHLORIDE)—General Remarks—Madras—Orissa—Bengal—Berar—Rajputana—Sambhar Lake—Didwana Lake—Kachor-Rewasa Lake—Bombay—Afghanistan—Punjab—Kohat—Bannu—Salt-Range—Gurgaon—Mundi — North-West Provinces — Assam—Chittagong—Burma. CARBONATE OF SODA (SODIUM SESQUICARBONATE)—General Remarks—Madras—Salem—Mysore—Berar—Lonar Lake—Central India—North-West Provinces—Oude. GLAUBER SALT (SODIUM SULPHATE)—General Remarks. REH—General Remarks. BORAX (SODIUM BIBORATE)—General Remarks—Kattywar—Kashmir—Thibet. SALTPETRE (POTASSIUM NITRATE)—General Remarks. SYLVINE. (POTASSIUM CHLORIDE)—General Remarks.

Salt or Sodium Chloride: General Remarks.—Salt is the mineral production, which is, of all others, the most important to the Indian revenue. The annual gross receipts received as tax on this commodity amount to about £7,000,000.

Since the year 1868 much has been accomplished with reference to equalising the duties in different parts of India, and coincidently with this many changes have taken place, certain sources of supply have been developed, while from others the outturn has diminished. The Government monopoly has been abandoned in some regions, while in others it has been established. It is not within the prescribed limits of this work to describe these changes, nor to detail the masterly arrangements by which the abolition of the Customs line has been accomplished.

While there are, as will be seen, several very distinct sources of salt in India, each of which is practically inexhaustible, there is still a steady import trade from foreign countries, and there appears to be no immediate likelihood of any diminution taking place.

The following sketch includes accounts of the most important sources of supply, but it does not pretend to be exhaustive, as that would involve an amount of detail which would not be of much practical use.

Madras.—The indigenous sources of salt-supply in Madras have been the salt-pans on the coastal districts, where, by the evaporation of sea-water, the salt is obtained. This manufacture, with various modifications from time to time, has been carried on partly as a Government monopoly, and partly under an excise system, by which the right to manufacture is leased to private persons, who have to pay duty on all the salt

they produce for consumption. A spontaneously formed salt obtained in swamps and lagoons is in most cases destroyed by Government officials, but at Pandraka in the Kistna district, and Vedarniem in the Tanjore district, salt of this nature is collected.

Up to within the past few years an untaxed manufacture of salt by lixiviation of saline earths was carried on in the interior districts of Madura, Bellary, Kadapah, Karnul, &c. Since 1879, however, measures have been taken for its complete suppression. Salt of similar origin used to be manufactured in Mysore. In all cases it was regarded as being inferior in quality to sea-salt, and was only used by the poorest classes. Madras generally is at present, however, largely dependent on imported salt for the supply of her requirements, though it would appear that an extension and improvement of the local manufacture, whether by monopoly or under the excise system, would result in a largely increased outturn, as a considerable part of the line of coast from Ganjam to Cape Comorin is available for the purpose. The following is an account of the plan which was generally followed in the manufacture of salt by solar evaporation in the Chingleput district:[1] "The manufacture begins in January as soon as the rains are over and the weather begins to get warm. The pans, which, including their reservoirs, are each two-thirds of an acre in extent, are first cleansed from the mud accumulated in them during the monsoon. Next day they are moistened with a little water and ridges are raised between the pans. On the third day the pans are dug 1½ inches deep with a kind of spade, and in the evening an inch of water is let in. From the 4th to the 9th day they are trodden down cross-ways. On the 9th day an inch of water, already well heated by the sun, is admitted. In the course of a few days a little inferior salt is produced mixed with brackish water. The pans are again well trodden down for four days, and water is admitted, which in four days more will produce good salt. From the 23rd to the 25th day the pans are pounded with rammers till the salt is quite destroyed, when an inch of water is again admitted. On the 29th day, when the water is a quarter of an inch deep, the salt is fit to be taken out. It is then stowed on the banks to dry for six hours, after which it is removed to raised dry platforms of sand and then stored in heaps of 60 tons or more."

The pans are not evaporated to dryness in order that the magnesium sulphate or Epsom salts may remain in solution, or a part of it, for the process is not very carefully conducted; a certain amount of calcium sulphate or gypsum is generally included in the salt.

[1] Chingleput District Manual, p. 307.

The above seems a complicated system, and one important part of the process, the preliminary evaporation of the brine in pits for 25 days or so, has been omitted from the description. In 1865 the Board of Revenue ordered that the brine should be reduced 50 or 75 per cent. in bulk before being admitted into the pans.

The French Settlements in India do not manufacture salt, in consequence of conventions entered into with and compensation received from the British.

Orissa.—Formerly the manufacture of salt on the coast of Orissa was an important Government monopoly. At present it is wholly in the hands of native capitalists. In Balasore and Puri the trade is said to be increasing, but it is declining in Cuttack. In some localities the evaporation is carried on by artificial means; in others by a solar process, similar in general principles to that practised on the coast of Madras. In Puri the water of the Chilka lake is used for the manufacture. The artificially evaporated salt is said to be the best, but having been cooked it is not used by the stricter Hindus. For further information on these subjects reference may be made to the Statistical Account of Bengal.[1] From Orissa and the northern districts of Madras, Ganjam, &c., a considerable quantity of salt finds its way into the Central Provinces and Western Bengal.

Bengal.—Formerly the Government monopoly of salt manufacture extended into Midnapur and Jessor, and salt from saline earths used also to be manufactured in the Patna district, but the industry is now extinct, and salt is no longer directly manufactured from any source in Bengal proper.

But indirectly a certain amount of salt, especially in Behar, is produced in the saltpetre manufactories. This product is subject to excise and has to be carefully watched by the excise officers.

Berar.—The sources of salt in Berar have formed the subject of numerous papers, and the Lonar lake especially has been accorded a considerable degree of notice. Over an area, about 50 miles in length and 10 miles in breadth, on both sides of the Porna river in Akola, wells used to be sunk, from which brine was obtained and considerable quantities of salt used to be manufactured by solar evaporation. Some of the wells close to Dahihanda are 130 feet deep. On the brine reservoir being tapped the brine spouts up with considerable force. In 1855-56, 398 of these wells were in working order and yielded to Government a revenue of Rs. 24,000.[2]

[1] Vols. XVIII and XIX.
[2] Wynne, A.B. Records, G. S. I., Vol. I, p. 3; and Berar Gazetteer, p. 22.

Rajputana.—There are four sources of salt-supply in Rajputana, as follows :—

(*1st*) From large shallow lakes without outlets,
(*2nd*) From earthworks, *i. e.*, the collection of saline efflorescence,
(*3rd*) From weak brine pits,
(*4th*) From deposits in old river-beds.

Although the lakes were the most extensive single sources of salt, the aggregate outturn from the other sources was very considerable. Thus, in favourable seasons, Bhartpur produced as much as 16,00,000 maunds of fair small-grained salt, but in 1876 this manufacture was closed as the result of treaties, and, moreover, because it was undersold by the salt from the Sambhar lake.

A brine pit in Bhartpur, which was examined in 1865, contained 20 to 30 feet of brine, at a depth of 20 feet from the surface; it was stated to have shown no diminution of supply for 28 years. There was at this spot no efflorescence on the surface to show the existence of salt below. In another well a section of 20 feet showed only the ordinary sandy and kankary soil common in the plains.

At Panchbadra, which turns out annually 11,00,000 maunds of good salt, the supply is obtained from wells which are dug in what is supposed to be an old bed of the Loni (Salt) river.

The principal salt lakes in Rajputana are Sambhar on the borders of Jaipur and Jodhpur; Kachor-Rewassa in Shekhwati; Didwana and Phalodi in Jodhpur; Lonkara-sur in Bikanir.

Sambhar Lake.—This lake is situated on the eastern side of the Arvali range, on the borders of Jaipur and Jodhpur. Its greatest length is 20 miles, and the average breadth about 5 miles. Its greatest depth near the centre, at the end of the rains, does not exceed 3 feet. The lake is merely a hollow in the middle of long ridges of sand, some of them 100 feet high, and under the lee of one of these it is protected from being filled up by blown sand. The drainage area is 2,200 square miles. The principal streams falling into the lake are two, one of which comes from 50 miles to the north-east, and the other from the neighbourhood of Ajmir, 40 miles to the south. The rocks occurring in the neighbourhood are, according to Mr. Hacket,[1] much disturbed schists and quartzites of the Arvali series. A tufaceous limestone is also abundant. Neither here nor anywhere else, where these rocks have been examined, has any bed been met with which would afford a source from whence the inexhaustible supplies of salt about to be described could

[1] Records, G. S. I., Vol. XIII, p. 197.

have come from. It has been suggested that under the concealment of the widespread sand, there may be beds of salt which are a marine deposit and coeval with the fresh-water Vindhyan sandstones, and that such beds, if they exist, may be a link between the great salt deposits of the Salt-range and the Vindhyan rocks of peninsular India. Another hypothesis is that there was here an arm of the sea in comparatively recent times, which on its retreat left behind it a salt-impregnated soil; still another hypothesis is that the salt is derived from the ordinary source of the saline waters of lakes which have no outlet except that afforded by evaporation,—that is to say, from the so-called sweet waters which, as is explained in the account of Reh, given in this Chapter, deposit under certain conditions saline matters to such an extent in some areas as to make cultivation impossible. Although it seems to be just possible, though perhaps not very probable, that research by borings may yet demonstrate the first to be the true hypothesis, still the facts, as at present known, on the whole favour the last hypothesis. These salt-producing lakes are in enclosed drainage basins. As already stated, the area of the Sambhar basin is 2,200 square miles, and the *primâ facie* conclusion is that the salt results from the concentration of the saline matter which follows from the high rate of evaporation.

The following is taken from a report by Mr. Adam for 1870-71. The specific gravity of the lake-water during the past rains was never less than that of sea-water, namely, 1·03, while the lake-water on the 30th July gave 1·03. In August it was the same. During September, the specific gravity stood at 1·04; in October, it rose from 1·05 to 1·07; in November, it varied from 1·08 to 1·10; in December, owing to some slight showers of rain, it was reduced to 1·095; in January, it increased from 1·11 to 1·14; in February, it increased from 1·15 to 1·20, and at this specific gravity salt began to be deposited.

When the brine reaches 1·8 operations are commenced, according to Mr. Adam, by cutting off portions of the lake by means of low walls of mud and grass. The salt forms in a crust which is over 2 inches thick on the fetid lake-mud, which is a foot in depth. The labourers lift this by placing their open hands between the salt and the mud and throw it into heaps, which are afterwards removed to store. This work lasts from March till the commencement of the rains; in the height of the hot weather the lake contains no water, but presents a dazzling roseate-white efflorescence. The crystals are generally in the form of truncated pyramids, and are of three colours, blue, white, and red. The

[1] Stray Feathers, Vol. I, p. 363.

red salt is not much esteemed, and the price obtained for the blue and white varies with the shade and perfection of the crystalline form. The natives evidently hold that salt loses its savour as the new salt of the year is always in most demand. For seventeen years before 1873 the average outturn had been from Sambhar 6,90,000 maunds (=25,346 tons), and the carriage then available for exporting the year's sales amounted to 3,00,000 bullocks, 66,000 camels, 18,000 carts, and 5,000 asses. At present the Sambhar lake has communication by rail.

In 1879 the outturn at Sambhar amounted to 30,00,000 maunds (=110,204 tons). This increase is partly due to the improved quality of the salt produced under British management, but it is perhaps chiefly attributable to the treaties with Native Chieftains, which have resulted in the closing of many inferior sources of supply.

"Sambhar salt has hitherto partially supplied the States of Jaipur, Alwar and Kishengarh, and has been largely imported *viâ* Bhewani, Delhi, Agra and Jhansi into British territory, besides mainly supplying the populations of the northern and eastern portions of Meywar, the Haraoti Agency, and Gwalior."[1]

Didwana Lake.—This lake, as described by Mr. Hacket,[2] is situated about 20 miles to the west of the Arvali range and 35 miles north-west from the Sambhar lake. It is about 4 miles long and 1½ broad.

During the rains there is about a foot of water, but this soon dries up. The origin of the lake is similar to that of the Sambhar lake. The mode of procuring the salt, however, differs essentially; wells are sunk to a depth of 15 feet and the bottom is pierced to a further depth of 2 or 3 feet, when brine suddenly rises with an evolution of sulphuretted hydrogen to within 4 feet of the top, and stands at that level, indicating the existence of a certain amount of hydrostatic pressure beneath the layers of sand and sandy calcareous tufa which are seen in the well sections. The brine is baled out and evaporated, the salt being produced, it is said, at the low rate of one rupee for 200 maunds!

The salt from hence has partially supplied the northern portions of Jodhpur and Bikanir and has been imported *viâ* Bhewani in considerable quantities into British territory.[3]

Kachor-Rewasa Lake is about 30 miles north of the Sambhar lake. The outturn in 1879 was about 15,00,000 maunds.

[1] Rajputana Gazetteer, Vol. I, p. 19.
[2] Records, G. S. I., Vol. XIII, p. 201.
[3] Rajputana Gazetteer, Vol. III, p. 19.

Bombay.—Salt is manufactured from sea-water on the coast of Bombay to a very large extent, and in the year ending 31st March 1880, there were 415 salt works[1] open, the revenue derived from which exceeded 15 millions of rupees. This salt is not only used in the Presidency, but is also largely exported to the inland provinces and even occasionally to Calcutta! From 1802 up to last year (1880) the British Government have had a half share with the Nawab of Cambay in certain salt works. The pans covered a space 2 miles long and a quarter of a mile broad. These works have now been closed except that the Nawab, who receives Rs. 40,000 annually as compensation, is allowed to manufacture up to 500 maunds for the use of his Court.[2]

Salt used to be manufactured from saliferous soils and saline waters in various parts of the Deccan, but the industry is probably now extinct, though carbonate of soda and saltpetre are still manufactured.

In Cutch the naturally formed salt on the Runn might be obtained in vast quantities, but it is only collected to a small extent and is not exported; nearly all the rocks, soils and waters of Cutch are impregnated with salt.[3]

There are accounts of large accumulations of salt in Sind, but they do not appear to have been used as sources of supply.[4]

Mr. W. T. Blanford[5] has described a very remarkable formation of rock-salt at the island of Hormuz in the Persian Gulf. Formerly salt used to be imported from thence to India.

Afghanistan.—According to Captain Hutton,[6] salt from three different sources used in his time to be sold in Kandahar. The first was obtained by lixiviation of a saliferous soil obtained in the Pishin valley; the brine was evaporated by boiling. A similar salt was prepared at Kuskh-i-nakud on the road to Giriskh. But the best was from Garmsael, where it was carried down in solution in the waters of a stream from the hills, which, spreading over a swamp, evaporated and left cakes of salt resembling ice. This account suggests the probability of the existence of rock-salt in these hills. Rock-salt is said to occur in Kohistan, and a sample of rock-salt was recently received from Pare Anguri in the Chakmani country.[7] The occurrence of rock-salt in Afghanistan is curious in

[1] Bombay Administration Report, 1879-80, p. 320.
[2] Bombay Gazetteer, Vol. VI, p. 208.
[3] Wynne, A. B. Mem., G. S. I., Vol. IX, p. 89.
[4] Selections from Records, Bombay Government, No. XVII, p. 705; and No. LIV, p. 61
[5] Records, G. S. I., Vol. V, p. 42.
[6] Cal. Jour. Nat. Hist., Vol. VI, p. 601.
[7] Procgs. As. Socy. Bengal, 1880, p. 123.

the face of the large export of Kohat salt, which takes place to Kabul every year, as is mentioned below.

Punjab.—While sources of salt-supply similar to those occurring in other parts of India are not wanting in the Panjab, this province is distinguished from all the rest by possessing enormous deposits of rock-salt. In connection with the fact of the occurrence of these deposits, the most remarkable circumstance is that, so far as is at present known, they do not all belong to the same geological age, but are referable to very distinct periods which are widely separated in time.

During the past year ending 31st March the weight of Panjab salt, upon which inland customs duty was paid, amounted to over one million and a half of maunds, or say 55,000 tons. This is exclusive of the salt manufactured in the Delhi division from brine; it only includes what has been raised from rock-salt mines.

The rock-salt deposits admit in the first place of a geographical arrangement into those which are trans-Indus and those which are cis-Indus. In the trans-Indus region there are the deposits in Kohat, and there are also deposits close to Kalabagh; the latter are merely a continuation of those in the cis-Indus Salt-range, while the former are of a totally different age. It will be most convenient to describe them first, and for this purpose the reports by Mr. A. B. Wynne and Dr. Warth[1] supply all the requisite information.

Kohat District.—The rock-salt of this area is at the base of the sections, no older rocks being seen. It is overlaid conformably by gypsum, which is again overlaid by rocks of nummulitic age; as no fossils have been found either in the gypsum or the salt, their age may be regarded as not being yet settled, but the presumption is that there is no break in time, and that they are therefore probably of eocene age.

In this region the salt is obtained by open quarrying, not by mining as in the Salt-range. The principal quarries are at Malgin, which have been worked from time immemorial; at Bhadur Khel, opened 12 centuries ago; and at Jatta opened in the year 1650.

At Jatta, Malgin and Narri gunpowder is employed for blasting the salt, but at Bhadur Khel and Kurruk it is obtained in slabs which are detached from the rock by pickaxe and wedge. The tools used by the quarrymen are a pick sledge called *koowar*, 12 to 20 seers in weight; a smaller pick, *sootak*; a crow or jumper called *jubber*; a needle for the blasting bore, *sik*; a spoon to clear the bore-hole, *kurrundi*; and a hand-barrow called *bangai*.

[1] Mem., G. S. I., Vol. XI, p. 209.

The Bhadur Khel slabs called *tubbs* are all of the same size, and do not require to be weighed. They are squares with a side of 18 inches and 4 inches thick, the stratification of the salt being availed of by the quarrymen. One man can cut from 16 to 20 of these *tubbs* in a day, and in this form the salt is sold. At Jatta the outcrops of salt extend over a space half a mile long and a quarter of a mile broad; in one place a thickness of 100 feet of salt was seen, but the base was concealed. At Malgin the salt crops out for a distance of 3 miles.

The quarries have generally a vault shape in order to support the superincumbent debris, and the system of working seems to be dangerous and wasteful. From the two above-named localities the average outturn is 1,00,000 maunds each per annum.

The quarries at Bhadur Khel are situated along outcrops fully 4 miles in length and from a quarter to half a mile in breadth. In the eastern half of this tract, the salt shows in a great number of outcropping exposures, while the western half is almost entirely of naked salt, patches of gypsum or earth concealing it being rare. In one place, where best exposed, the thickness is at least 100 feet, most of it fit for excavation. The only admixture consists of occasionally interspersed clay; no foreign salts are included.

The authors quoted give very full details regarding individual quarries, from which it is unnecessary to quote further here. There are said to be 335 distinct exposures of rock-salt, exhibiting approximately 3,082,996 superficial feet of salt. Taking an average thickness of 200 feet for the whole area in which the salt is known to occur, the total available quantity is estimated at 40 millions of maunds, which, allowing for waste, would at the present annual rate of consumption last for 40,000 years.

The Government tax on this salt is trifling, and its importation eastward of the Indus is prevented by the customs line. It supplies a computed area of 60,000 square miles, including most of the Derajat and a large part of Afghanistan,—even, it is said, reaching Kandahar.

Bannu District: KALABAGH.—The salt at this locality is of the same age (silurian ?) as that about to be described in the cis-Indus Salt-range, and it is therefore presumably much older than that in Kohat. According to Mr. Wynne[1] it has been traced along the Lun nala for a distance of about 2 miles from the Indus, opposite Mari, and is reported to occur again 9 miles up the valley.

The salt is worked by open quarries and small drifts, and the beds, which are worked, vary from 4 to 10 or 20 feet in thickness, and there are

[1] Mem., G. S. I., Vol. XIV, p. 274.

alternations of good and bad salt. Much of this salt occurs in a crystalline condition, transparent cubes of several inches on the side being obtainable. The age of the salt which is reported to exist higher up the glen is not yet known. The salt raised at Kalabagh is carried eastwards or across the Indus, being subject to the high duty.

Salt-Range.—The rock-salt of the Salt-range is the oldest known deposit of salt in the world. As it underlies beds containing silurian fossils, it belongs to a period not younger than silurian. Thus it is much more ancient than the Kohat salt, which, as has been above stated, is probably of eocene age.

In consideration of the high importance of this deposit, the following somewhat lengthy quotation from Mr. Wynne[1] is given. Not only does it contain Mr. Wynne's own original remarks, but it is a *résumé* of the observations by others, especially of those by Dr. Warth:—

"It appears that the mines were formerly much more numerous, and, under native management, merely consisted of small openings at first, which were afterwards unsystematically enlarged, until they became dangerous. Since the annexation of the Punjab, it has been found useful for facility in collecting the revenue, to lessen their number greatly, and still further reduction has been proposed or lately carried out.

"The mines open during the progress of the Geological Survey were those of Khewra, Sardi, and Varcha, on the eastern side of the Indus, and the open quarries of Kalabagh beyond that river. Besides these, an experimental driving was being sunk (and is intended to be carried on from time to time) beneath the southern cliffs of Mount Tilla, in order to prove the existence or absence of workable salt within reach, that point being so much nearer than the others to the Northern State Railway. Up to the latest information the salt had not been reached.

"The largest mines of the range are the Mayo mines at Khewra, so called to commemorate the visit of a late Viceroy. In these, vast but dangerous chambers had been left by the old Sikh workmen, who either knew or cared so little how or where they worked, that two heavy pillars supporting the roof of one excavation were left resting upon a thin crust of salt, spanning another large chamber below. It has been remarked that most of the roof-falls of the mines took place at night, and the miners, who work only in the day-time, may have relied on this poor chance of safety. As it was a matter of great uncertainty how long these pillars would remain supported, instead of supporting the roof above, their removal was ordered, when suddenly, on Sunday the 5th of June 1870, one of them broke through, carrying with it a large part of the roof, and forming a crater on the hill in which the mines are situated. The fallen mass of salt and marl was

[1] Mem., G. S. I., Vol. XIV, p. 284.

estimated (by Dr. Warth) at half a lakh of maunds, from which the damage that might have been done, had there been miners at work beneath, may be imagined.

"The present state of these mines differs widely indeed from that which existed during the earlier visits of the Geological Survey Officers to the place, and still more from the state of things described by Dr. Fleming and Mr. Theobald or previous writers. When I was going through them first with the Deputy Collector formerly in charge, his kindly warnings not to remain in certain places were repeatedly given, but now, even though the mines are far from being everywhere safe, the alteration in them is so great that an air of security is derived from the regularity of the new works, and the business-like manner in which the operations are being carried on. Since Dr. Warth took charge, this great improvement has been effected, though improvements upon the old systemless plan of working were of course in progress ever since the British rule began, as evidenced by the very names of workings like "Thompson's drift," "Purdon's tunnel," "Mathew's drift," &c. Only a few years since, entrance to the mines was gained down a slippery incline, or through an adit, but now one can drive in upon a tramway, through a spacious passage, and observe a system of regular pillars and openings, with various inclined and other drifts, leading to a main passage, through which the salt is taken out of the mine in trucks. In former days, the two principal mines here (the Baggi and Sujewal mines) were disconnected, and both of them ill ventilated: a passage has now been open from one to the other, which not only gives a fine rush of air through the mine, but offers an additional means of escape for the numerous workmen in case of danger.

"The old chambers, however, still remain to contrast with the new system, and when lighted up the effect of these great caverns is very picturesque, particularly under the influence of coloured lights or that from the magnesium lamp; but it is only in very strong lights that the brilliant reflections from the facets of crystals become at all prominent, though frequently spoken of by previous writers, before blasting powder was so much used; nor are stalactitic masses so common as one might expect.

"The method of working in these Baggi and Sujewal mines is described by Dr. Warth in his first paper previously referred to, from which the following is condensed:—

"'The miners work in three different ways in the Baggi mine. First forward from a certain floor into the rock-salt. This is called the *katti* (*kuttee*), and is the most troublesome. It is nearly as hard as cutting drifts there being a good deal of pick-work before the men can blast. As the *katti* is carried forward, they gradually work the roof down, sitting upon tripods, some of which are 25 feet high. This is called *chhat* (*chutt*)[1] work.

[1] From the word pronounced "chutt," meaning roof or ceiling.

When they have advanced with the *katti* and *chhat*, they begin to work from behind downwards. This is called the *par* (*pur*), or deep working. This *par* ought to be very easy work, but it is not because from want of space it cannot be carried on in regular advancing steps; instead of this, the miners work the *par* directly downwards over areas marked out to them, both in the Baggi and Sujewal mines.'

"Dr. Warth proposed to operate in a contrary manner, namely, to work the *katti* on the roof of the salt seam, and the remaining salt down to the bottom as *par* by steps. The improvements are being gradually carried out, and the appearance of the mine is yearly changing in consequence, so that in course of time there is little doubt the system will become as perfect as possible. Not very long ago gunpowder was never used; now its advantages are fully felt, and Dr. Warth has fired some large blasts separating hundreds of maunds of the salt at once with perfect safety.

"From one of the smaller mines called Phurwalla, men, women, and children had carried full 40 lakhs of maunds of salt up a narrow steep and crooked drift, and from the whole Mayo mines Dr. Warth estimates the gross amount of salt removed at 300 lakhs of maunds; but notwithstanding the length of time these mines have been extensively worked, and though each season adds a concentric belt to the excavated area, they show as yet no signs of becoming exhausted.[1]

"In order to facilitate the carriage of the salt from the mines, Dr. Warth's tramway has been extended to the mouth of the gorge, and thence a wire-rope tramway has been constructed under the superintendence of Lieutenant DeWalski, R.E., to the village of Chak Nizam, on the southern bank of the Jhelum, above Pind-Dadan-Khan, and 10 miles from the Khewra gorge. This has been for a few months completed, and is occasionally in working order, but difficulties have had to be contended with in the unusual length of the line, and the effect of the water of the country upon the boilers of the engines that supply the motive power. When fairly at work, this tramway will be an important aid in the rapid distribution of the salt by means of the Northern State Railway.

"The Sardi mines to the west (10 miles or so north-westward from Pind-Dadan-Khan) are smaller and less favourably situated for working, being sunk below the bottom of the glen instead of in a hill-side like those of Khewra. They were more recently opened than the latter, and were originally constructed on a better plan, flights of steps being cut out of the salt, and the roofs supported. Owing to their low situations they have been at times stopped by access of water, and I believe they are now altogether closed.

"The Varcha (or Wurcha) mine is in the hill on the right-hand side of the Varcha gorge, about 30 miles west-north-west from Shahpur. The

[1] For very full descriptions of the mines, modes of working, outturn, &c., Dr. Warth's papers may be referred to.

mine is at a considerable elevation, and is large, though only about 20 feet of salt are excavated out of a bed of much greater thickness,[1] the remainder of which is not sufficiently good for commercial purposes at the Salt-range. There are large remains of old Sikh workings and great natural shafts or vertical water-courses. The old workers here, as elsewhere, left the roof unsupported, and it is falling in, but in the modern mine this is provided against. While the salt-bed continues to dip as it at present does 20° to north-west, no alteration in the mode of working (according to Dr. Warth) will be needed. The mine is well ventilated and clean, and has two modes of ingress, but no low-level water escape.

"The Kalabagh workings are all 'at day-light,' in a thick group of salt-beds, ranging from 4 to 10 or even 20 feet each. They run along the right side of the Lun or Gossai nala (or Drung gorge), the salt being found to extend from the base of the hill as high up as 200 feet, but the beds are not all sufficiently good to be worked, 20 feet being the largest known thickness of a workable salt-bed here. All the beds dip west at nearly 70°. The salt outcrop extends for some 2 miles up the glen, and there are fourteen working places or quarries.[2]

"Besides those mentioned there are numbers of old mines, about which nothing is known, while some that have been inspected were found to promise large supplies of salt. Several of the old mines occur in the Jutana and Kusak beats, four in the Makrach beat, three in that of Malot; eight in Sardi beat, four in the Nilawan ravine, three in the hills about Musa-khel, and several at Mari.

"The old Jutana mines were being worked when Dr. Jameson visited the Salt-range in 1843, and had then been open respectively twenty, thirty, and thirty-five years. The descent into the body of the mine was accomplished by steps cut in the salt, and the workings seem to have been large, but as irregular as usual in the Sikh excavations. The salt was removed in masses, two of which were a load for a camel; also in smaller pieces with which to load oxen. The miners were paid one anna per maund for extracting the salt, and this was sold for a rupee per *pakka* maund. The price of a camel-load was Rs. 6 to 8, and before it reached Amballa, paying hire, duty, &c., it cost from Rs. 8 to 20.[3]

"The best idea that can be given of the quantity of salt produced by the Salt-range mines will, perhaps, be obtained from the value according to the subjoined abstract of the receipts for four years (taken from the report on the administration of the Inland Customs Department for the official year 1870-71, page 147). The rate at which the salt is sold at the mines is Rs. 3-1 per maund[4]:—

[1] Dr. Warth remarks that the salt mines of Cheshire are being excavated in the same thickness as the Varcha bed, namely 20, feet.

[2] Dr. Warth. Appendix, Inland Customs Reports, 1869-70 and 1870-71.

[3] Dr. Jameson's Report, Jour. As. Soc. Bengal, Vol. XXII, p. 183.

[4] Rs. 3-1=six shillings and one and a half pence. A maund is equal to 82 lbs.

Receipts from the Salt-Range Mines.

Years.	Names of Mines.				Total.
	Mayo.	Sardi.	Varcha.	Kalabagh.	
	Rs.	Rs.	Rs.	Rs.	Rs.
1867-68 . .	28,97,530	1,91,819	2,83,783	2,16,189	35,89,321
1868-69 . .	29,10,338	2,50,506	4,16,292	2,03,445	37,80,581
1869-70 . .	35,03,171	4,26,485	3,99,856	1,61,946	44,91,458
1870-71 . .	27,99,092	4,20,686	4,45,040	1,99,584	36,64,402
				Total .	1,55,25,762

This total (taken at par) is equal to £1,552,576, or an annual average amounting to the large sum of £388,144.[1] It appears from the same report, page 15, that the average amount of salt cleared from the depôts during the above years was 12,91,148 maunds.

"With regard to the continuity of the salt-beds, the indications, so far as can be judged at present, point to the occurrence of several sets of beds, rather than the extension of any one group, and the quantity of salt, as now known or exposed, probably bears only a small proportion to that which is concealed, or which may have been destroyed. Mines have been worked along the range from periods so remote that their dates cannot be ascertained,[2] and very much of the salt has been both naturally and artificially removed, yet if the present outturn were increased many times, the supply might still be considered inexhaustible, so far as quantity is concerned. The salt-marl appears so frequently that its continuity, for a distance of 134 miles, more or less, can hardly be doubted, and it occupies a breadth which, on the same sort of evidence, may be fairly assumed at from 4 to 5 miles, while its reappearance on the north side of the range in two places would indicate its underlying the mountains everywhere, with a breadth of from 12 to 16 miles, or it may extend to a much greater width.

[1] This is the average taken from the above figures; that given by Mr. Wright, the former local head of the Salt Department, is smaller by nearly £5,500, but he may have deducted some working expenses of the Department.

[2] "Dr. Fleming records that the mines were first worked in the reign of Akbar, and mention is made of them in the *Ain-i-Akbari*, but this is all the information existing upon the subject. The native tradition is that Akbar was informed of the existence of salt by a certain Asp Khan on condition of his receiving, as a reward, during his life-time, a sum equal to the whole of the wages of the miners employed in digging it. Salt was sold in Lahore during the reign of Akbar at the rate of 6 annas per maund."—*Punjab Government Gazetteer, Jhelum District.*

Allowing a breadth of 5 miles, this estimate gives an area of salt-bearing marl 670 square miles in extent, in which the salt-zones vary from nearly 100 to 275 feet in thickness, separate beds or groups of beds of salt, where the size of the bands collectively is least known, having thicknesses of 20, 30 and 40 feet.

"Excepting for about 12 miles in length, at the eastern end of this area, salt is seen or known to exist within almost every mile where the marl is fairly exposed, so that although little or nothing is known as to the manner in which the salt-zones are laterally extended or terminated, the quantity of the mineral present must be enormous if it is considered that (a roughly-shaped cubic foot of salt weighing about 136 pounds) the solid contents of a bed of salt, only 30 feet in thickness and 1 square mile in area, would amount to over 50,778,514 tons.

"The detailed accounts of the mines given in publications already referred to being very copious, it has been sought to convey here a fair general impression of the deposits, rather than reiterate all the details previously published.

"The new facts ascertained by the latest explorations are chiefly these :—

(1.) Where the workings have been most carefully surveyed the salt has been found in zones consisting of several distinct beds within distances of about 600 feet, 200 feet, and less, of the top of the marl and gypsum.

(2.) That the arrangement and thickness of the beds and the quantity of marl and gypsum (more or less intermixed) intervening between the salt-zones, and between the group superior to the marl and the salt itself, indicate more variability than sameness of the exact horizon upon which the salt is found.

(3.) That there seems to be a larger development of so-called bad salt in the western than in the eastern part of the district (which bad salt would, however, in other districts be extremely valuable).

(4.) The recent and most detailed explorations by the Salt Department have been chiefly confined to the old workings, and other beds of salt have not been sought for, except at Mount Tilla, where none has yet been found. Without regular prospecting operations it would be impossible to hope for information about the salt-rock in this or other directions, partly on account of the tendency which the marl has to conceal the enclosed salt; and whether the lower part of this "red marl" does or does not also contain valuable beds of salt is quite unknown.

"Should it ever become necessary, the best place, perhaps, for ascertaining this would be the ground about Chambal hill (west) between the Jutna and Kusak beats.

"Though the method of mining the salt is being improved, and arrangements for its transport by wire-tramway and rail from Khewra are in progress, the old system of carriage still exists elsewhere, together with the waste this occasions. The salt is reduced to rough spherical lumps, to prevent the corners being rubbed off during its rough transport in open nettings or hair-cloth bags. So long as the merchants prefer, and can obtain, the salt in blocks, it does not seem likely that any steps will be taken to utilise the enormous quantity of valuable salt now wasted."

Gurgaon District: SULTANPUR AND NUH.—Formerly these sources of salt-supply were of greater importance than they are likely to be in the future, as the cost of manufacture is comparatively high, and the facilities for carriage to the principal markets are less than those enjoyed by the Sambhar salt; at the same time the quality of the salt, especially that made at Nuh, is inferior.[1]

The sources of supply in this case, as in some of the adjoining States of Rajputana, are brine wells or *surrs*, the water-level in which is from 14 to 23 feet below the surface, sometimes even 40. The brine is evaporated by sun heat in shallow chunam-lined pans, which are connected with one another, and the brine is passed through the series in from 12 to 20 days, according to season. The chief art in the manufacture, where foreign salts are included, consists in running off the mother liquor from the last pan at the right moment when the salt or sodium chloride has crystallized out, but while the other more soluble salts are still in solution; where this is not done the salt is impure, and brings a low price.[2] Fifteen years ago, the outturn and sale of salt from these sources used to exceed half a million of maunds, but the trade appears to be becoming extinct.

Mandi State.—The geological age of the salt deposit in this State has been discussed in a previous part of this work (Part II, p. 558), the conjecture being that it is probably of nummulitic age, though the beds including it have become so disguised as to present apparent affinities rather to the older lower Himalayan rocks than to the tertiaries of the sub-Himalayan series. The salt is of a dark-purplish hue, is opaque, and contains about 25 per cent. of earthy matter according to Mr. Medlicott.[3] Small nests of pure crystalline salt occur but rarely, and they are reserved for the use of the Raja and his family. The mines or quarries are at Drang and Guma, 14 miles apart. These mines used to

[1] Report on Inland Customs Department, 1879-80, p. 12.

[2] *Op. cit.*, 1867-68, p. 32. A full account of this manufacture is given in Panjab Products, p. 74.

[3] Mem., G. S. I., Vol. III, pt. 2, p. 60.

be worked in the most slovenly fashion, being open to the drainage and falling-in every year during the rains.

Under the present existing arrangements more system has been introduced. In 1879-80, the total quantity of salt raised amounted to 1,30,622 maunds, of which 78,841 maunds went to British territory and 51,781 to Native States. In future, the British Government is to receive two-thirds of the duty on gross sales, and the Mandi darbar one-third.[1]

North-West Provinces.—Salt used formerly to be manufactured to a considerable extent in several districts of the North-west Provinces from saline soils, which, as they contained other salts besides sodium chloride, yielded an impure product, including sodium and magnesium sulphates, sodium carbonate, nitre, &c. In the Bulandshahr and Muzaffarnagar districts, especially in the vicinity of the Jamna, this industry was most active. Information on the subject will be found in the papers quoted in the list of references (Appendix E), and especially in the North-West Provinces Gazetteer. A certain amount of salt from Thibet crosses the Himalayas, and is used in the Hill States, and to some extent in Kumaun and Garhwal. In 1870 the estimated imports into these districts amounted to 9,000 maunds; it is brought with borax and is obtained in the same regions.

Assam.—Formerly salt used to be manufactured to some extent from the brine springs which often occur in association with those of petroleum, as has been mentioned in Chapter II. At Borhat and Sadiya, in Lakhimpur, there are for instance springs which were formerly worked; those at the latter in 1809 yielding 1,00,000 maunds of salt, and a revenue of Rs. 40,000.[2] In Cachar the right of manufacturing salt is still leased out, but the revenue from this source has much decreased of late years, and the indigenous article has now almost given way to English and other salt imported from Bengal. The lease in 1875-76 only brought Rs. 37. In the Nowgong district, the existence of a regular salt mine at Jungthang has been reported, but it perhaps requires confirmation.[3] In the old manufacture the vessels used for boiling down the brine were simply the internodes of bamboos which were pared so thin that the percolation of the moisture prevented their burning.

Chittagong.—Salt-licks and salt-springs are known to exist in several parts of Chittagong. Of the former the principal are at Bhangamura in the north and Mawdang Klang in the east of the Chittagong

[1] Report, Inland Customs Department, 1879-80, p. 10.
[2] Robinson's Assam, p. 33.
[3] Statistical Account of Assam, Vols. I and II.

Hill Tracts. Two salt springs flow from the Lungshem range at lat. 23° 28′ and lat. 23° 17′ and about lat. 23° 37′; under the true Sorphuel hill a third is reported. The Kukis manufacture salt by boiling down the water in conical earthen pots arranged in rows over a low flat fire-place.[1]

Burma: Pegu Division.—Mr. Theobald[2] has published a special account of the salt springs of Pegu, which are distributed at 79 different localities, all of which are situtated in tertiary rocks, miocene and eocene. No salt springs are known on the western side of the Arakan range, nor on the eastern side of the Pegu range. Formerly there was a considerable manufacture of salt from the brine obtained from these sources, but of late years it has to a great extent ceased owing to its inability to compete with salt manufactured on the coast and foreign-imported salt.

The brine used to be evaporated in iron pans or in earthen pots, the process being somewhat different from that in practice on the coast, where the ovens are of a beehive shape, the earthen vessels resting in holes all over it, but iron pans are also sometimes used on the coast.

According to the British Burma Gazetteer this coast manufacture, which used to be practised from Akyab to Mergui, is being extinguished by the imported article, though still holding its own in Southern and Central Tenasserim. The duty levied is much smaller than in India.

Upper Burma.—Even in Upper Burma, according to Major Strover,[3] imported salt is making its way against that produced from indigenous sources. Extensive salt-fields, the exact nature of which is not quite clear, are said to exist at Simpagah above Mandalay, and some of the hill people like to mix this salt with that obtained from Europe.

Sodium Carbonate, or more properly the hydrous sodium carbonate, is generally spoken of simply as carbonate of soda. It is found as an efflorescence in certain soils, and is deposited from the waters of some lakes.

The principal uses of this salt are connected with bleaching, washing, dyeing, and the manufacture of soap and glass, &c. Owing to the large quantities of sodium carbonate which are now manufactured from common salt, the natural product has fallen very much in value; formerly it used to be prepared from kelp, but the other products of kelp, such as iodine, are now of chief importance in that industry.

In India sodium carbonate not only occurs in certain areas in the soil, but it might be largely manufactured in those regions where reh

[1] Statistical Account of Bengal, Vol. VI, p. 29.
[2] Records, G. S. I., Vol. VI, p. 67.
[3] Indian Economist, Vol. V, p. 14.

efflorescence abounds, more especially in those where this efflorescence consists largely of sodium sulphate, which by calcination with kankar and charcoal might be changed into the carbonate; in those cases where sodium chloride is intermixed the addition of sulphuric acid would be necessary to get rid of the chlorine.

The Lonar lake in Berar is the most considerable natural source of sodium carbonate in India.

Madras: Salem District: BARAMAHAL.—In this region, according to Captain Campbell,[1] crude carbonate of soda occurs in patches of soil resting upon kankar. By a very simple process of lixiviation and evaporation a pure carbonate, free from any sulphate or chloride, could be obtained.

He proposed the manufacture on a large scale, as he believed that this product would have a better chance of competing in England than had some which had been prepared by the reduction of the sulphate, but which had failed to meet with a profitable market.

Glass-makers and washermen were in the habit of manufacturing this carbonate of soda, which supplied a considerable area all round.

Mysore State.—Among the Chitaldrug hills carbonate of soda is somewhat abundant, but is much mixed with common salt. Dr. Heyne states that is was sold in the bazaars under the name *sabboo*, and was used for the same purposes as that obtained in Salem.[2]

A similar mixture of salts used to be collected in Hyderabad from the granitic soil.[3]

Berar: Buldana District: LONAR LAKE.—There is a very abundant literature referring to the peculiarities of this remarkable lake, and already a description of it has been given in Part I, page 379 of this work, in which the crater-like hollow, which is more than a mile in diameter, is attributed to a volcanic explosion, which was, however, unaccompanied by any trace of eruption in the surrounding rocks. That it was not formed by any form of superficial aqueous denudation is certain, but it seems possible that in spite of the raised rim formed of loose blocks, it may have been formed by subsidence caused by the formation of a huge hollow or cave in calcareous rock underneath. Subsidences arising from the giving way of the roofs of such hollows under the weight of superincumbent strata are not uncommon in limestone countries, and it is not altogether improbable that limestone (lameta) rocks may underlie the basalt at this locality.

[1] Trans. Bomb. Geogl. Socy., Vol. VI, p. 163; and Jour. As. Socy. Bengal, Vol. X, p. 159.

[2] Tracts, p. 45.

[3] Walker, Dr. Madras Jour. of Lit. and Sci., Vol. XVI, p. 187.

In so far as the present account is concerned, the only point to be noted is that blocks of mixed salts are obtained by divers in certain parts of the lake, and that the waters of the lake, on evaporation, deposit salts, among which the principal is carbonate of soda; cubical crystals of common salt, sodium chloride, are also deposited, but in what proportion is not stated. The local names for these products are *dalla,* which consists of a close collection of acicular crystals, between two compact surfaces; *kuppal,* a thin kind of *dalla,* principally of red colour; *papadi or papri,* a white saline froth.

In the following table of analyses by Dr. J. B. Lyon of Bombay a somewhat different nomenclature is adopted:—

	Dalla.	Nimak Dalla.	Dallaka Chura.	Papri.	Bhuski
Chloride of sodium . .	9·34	12·55	7·89	29·30	24·28
Soda	29·43	29·79	27·34	11·49	4·84
Carbonic acid . .	29·64	27·54	26·63	11·21	4·64
Water and organic matter	28·45	26·21	31·95	23·96	23·40
Insoluble residue . .	3·14	3·91	6·19	24·04	42·84
	100·	100·	100·	100·	100·
The soda is equal to neutral carbonate.	50·31	50·93	46·74	19·64	8·27

The price of the *dalla* appears to vary from Rs. 75 to Rs. 125 per *kandy* (= 500 lbs. ?), while the *papri* is worth only from Rs. 18 to Rs. 25, and the *bhuski,* Rs. 8 to Rs. 10.

According to the native account there are two very deep portions of the lake, one having an area of 2 to 2½ and the other of 1½ to 1¾ acres, in which the brine is concentrated when the waters retreat. The divers do not venture into these hollows, as they believe that to do so would cause certain death owing to the thick slimy mud. The statement that the solid crystalline *dalla* can only be obtained by the divers when the lake is full seems strange if true. The *papri* and *bhuski* are got in the hot-weather on the dried-up margins.[1]

The successive annual reports of the Assigned Districts give accounts of the operations and financial results connected with the collection of these salts. In some years the profits have exceeded Rs. 20,000, but of late years the sale and also the outturn have fallen considerably. The sale has been much affected by heavy duties imposed on the imports into Hyderabad, and the outturn has been reduced by heavy rainfall. Owing to an impression that the lake requires rest, the products have not been collected at all in some years. Various experiments have been made to increase

[1] Captain K. L. Mackenzie. Berar Gazetteer, p. 24.

the outturn by cutting off the supply of water and also by isolating portions of the water in pans or pits. As the salts are very probably brought in by the river-water, the result of cutting off the supply may very possibly have exactly the opposite effect to that which is desired.

From the last of the above-mentioned reports it would seem that the latest selling price has not much exceeded one rupee per cwt.

Central India: Malwa.—In the bed of the Chumbul river, where it traverses basaltic rocks, carbonate of soda has been found on the margins of pools; the first recorded discovery was by Captain John Stewart in 1819.[1]

North-West Provinces and Oudh.—In these provinces, and also in Behar, the manufacture of *sajji* and *rassi*, two varieties of carbonate of soda, from saline earths, is carried on under licenses, as is also that of saltpetre (*shora*) and sulphate of soda (*khari*). The object of the license system is principally to protect the revenue, as in some of the factories a considerable amount of common salt, sodium chloride, is educed, and on this alone the duty amounts on the average to about Rs. 1,00,000 per annum.

In Northern India and Bengal alone there are over 40,000 petty factories for the preparation of crude saltpetre, sulphate of soda and carbonate of soda.

Sodium Sulphate.—The hydrous sodium sulphate or glauber salt is largely produced as an efflorescense in certain soils, and it is a common constituent of *reh* in India, the proportional percentage which it bears to other salts of soda varying with the localities.

Whether produced naturally or by artificial means, its principal use is in the preparation of sodium carbonate. *Khari*, as it is called, is now, however, largely used for curing hides, for which purpose it is better suited than common salt, owing to the tendency of the latter to absorb moisture. The *khari* of Behar is purer than that from the North-West Provinces, which contains a much larger proportion of sodium chloride. Patna *khari* is at present, therefore, now in large demand by tanners.[2]

It would be useless to attempt to give details as to the distribution of this salt—indeed complete information is not available.

In some cases the salt-licks which are frequented by cattle yield this salt chiefly. Such is the case all along the outcrop of the Damuda rocks at the foot of the Darjiling hills, where the licks are much resorted to also by elephants, rhinoceros, deer, and other wild animals.[3]

[1] Trans. Lit. Socy., Bombay, Vol. III, p. 53.
[2] Administration Report, Inland Customs, 1879-80, p. 38.
[3] Mallet, F. R. Mem., G. S. I., Vol. XI, p. 90.

Reh: General Remarks.—*Reh* is the native term applied to efflorescent salts which have accumulated in the soil and subsoil waters of large tracts in India, to such an extent in some places, especially in Northern India, that cultivation has become impossible; in the Upper Punjab *kallar* is a common name for the same substance. As affecting the general prosperity and revenues of the country, the subject of how to mitigate or diminish the evil has naturally attracted a good deal of attention, and numerous reports and papers have been published which contain more or less trustworthy information, and more or less of practical suggestion.

Before stating what these salts are, it will be well to briefly describe their source and origin. For full information on the subject, in its economic aspects, reference should be made to the papers of which the titles are given at the end of this volume. In the first part of this work (vol. I, page 413), a *résumé* of the subject has already been given, but in spite of the repetition necessarily involved, it is thought that in the present account of the economic geology it is advisable to re-state the leading facts again.

Primarily the saline matters are derived from the decomposition of rocks, and, taking the case of Northern India, the rivers descending from the Himalayas carry down in solution proportions of salt which vary with the character of the strata traversed. The salts so carried in solution consist principally of calcium and magnesium carbonates and sodium sulphate and chloride. In addition of course the alluvium or silt which is brought down, consisting of finely comminuted minerals, includes materials which, on decomposition, are capable of supplying bases for the ultimate formation of the same salts under suitable conditions.

In a region of intense evaporation, and where there is not a free drainage outlet of water, these salts, by long-continued concentration, accumulate in the soil or in the subsoil waters, and over and above this rain-water charged with carbonic acid, falling on a porous soil, has the effect of decomposing its mineral constituents, and of carrying down the salts so formed in solution either to the region of subsoil water, or else for only a few inches or feet below the surface. When the surface of the ground again becomes dry, this saline water rises by capillary attraction and evaporates, and a salt efflorescence remains, which at length so permeates the superficial layer of soil that cultivation becomes impossible. With free underground drainage, which would admit of the rain passing through and washing the soil, this would not occur, especially where the surface was well protected from evaporation by vegetation.

Irrigation by canal water, when not accompanied by deep drainage,

has had the effect of increasing the amount of reh deposit, and large tracts have been in consequence thrown out of cultivation. The indirect action which has produced this result has been fully explained by Mr. Medlicott.[1] In this case, the direct increase in the amount of saline matter is inconsiderable owing to the comparative purity of the canal water; but the so-called table of subsoil saline water has, by the addition of irrigation water, without an increase in the drainage, had its level raised to an extent which has rendered capillary attraction operative, and so these saline waters, which were previously to a great extent innocuous, have been brought into injurious contiguity with the superficial layers of soil. Thus is explained the apparently paradoxical fact that irrigation, by comparatively pure canal water, has been followed by an increase of salts in the superficial soils.

A very exhaustive paper on the subject of *reh* by Dr. Center[2] gives an interesting account of the methods which are adopted by farmers in the salt-lake region in America to cure lands which are similarly affected as are the sterile tracts of India. Among these, thorough washing of the superficial soil, and the removal of the salt by solution, heavy manuring, and protection of the surface from evaporation, have been tried with good results, and sterile land has been brought under cultivation.

The uses to which *reh* may be put have been enumerated by Dr. Center. Sodium sulphate for medicinal purposes can be easily obtained from it, and where it is abundant it might be used to manufacture into the carbonate for glass or soap manufacture. The natural average mixture of sodium sulphate and sodium chloride is similar to that produced by the manufacturers of sodium carbonate, who add sulphuric acid to common salt. By evaporation a salt cake of sodium sulphate might be obtained free from sodium chloride, and with the aid of charcoal and kankar the rest of the process might be performed. Sodium carbonate itself, as already stated, occurs in some abundance in certain of these soils. In former times an impure salt for commestible purposes was largely manufactured from the *reh*, but it was naturally very much mixed.

It has been proposed by Dr. Brown to cure the soil by the application of lime nitrate, which may easily be obtained by mixing pounded kankar with manure; by double decomposition, it would produce alkaline nitrate and calcium sulphate, the sodium carbonate would also be neutralised; but the sodium chloride would remain unaltered.

[1] Selections from Records, Government of India, No. XLII, p. 32 (1864).
[2] Records, G. S. I., Vol. XIII, p. 253.

Borax: General Remarks.—Borax or the hydrous sodium bi-borate occurs naturally in white transparent oblique rhombic prisms, which belong to the monoclinic system. It occurs as an exudation on the surface of saline soils, and often in connection with salt lakes. It was first taken to Europe from Thibet, and it carried with it the name *tinkal,* which name it still retains to some extent. According to General Cunningham, the Thibetan name is *tshale.* It is now obtained largely in California and Nevada, and is also manufactured in the lagoons of Tuscany by the reaction of boracic acid on sodium carbonate. The pure acid is obtained in a crystalline form by passing the vapours given out by numerous fumeroles through leaden tanks full of water, which is evaporated by the heat of the vapours themselves.

Borax is employed in the manufacture of artificial gems and fine glass; in enamelling and soldering; as a flux in metallurgical and blow-pipe operations, and as an ingredient in certain varnishes, toilet soaps, and cosmetics; it is largely used by workers in metals in India, also as a constituent of varnishes and as a medicine.

Within the limits of British India, there is no known source of borax, the supply being all imported from Kashmir or Thibet.

Kattywar.—In the year 1787, Dr. Hove, a Polish savant, was employed by the ministry of the day to travel in and report upon the cotton districts of India. At a place called Serapur, near Limri, he heard of the manufacture of a crude borax from an earth which was obtained at some locality four days' journey off. It was fused on copper pans being protected from the air, and when molten conveyed into a vessel of water. It was exported to Surat and Bombay. There does not appear to be any recent information regarding this source.

Kashmir: Puga.—Borax is obtained in the Puga valley, where it owes its existence to numerous hot springs, some of which have a temperature very nearly equal to the local boiling point of water, namely, 178° F. It is found precipitated with common salt on the banks of the streams forming a white crust. This is collected and purified by solution. The average export was in 1863, according to Dr. Stoliczka,[1] 4,000 maunds; but it is not stated what maunds; the local maund or sheep-load in Ladak is only equal to 16 seers. The trade is not now of much importance. About 30 years ago M. Marcadieu[2] was deputed, at the instance of some masters of potteries in England, to report upon the possibility of increasing the trade, but it would seem that they subsequently withdrew from

[1] Mem., G. S. I., Vol. V, p. 131.

[2] Selections from Pub. Corresp., Punjab, 1855, Vol. II, No. 12.

embarking their money in so remote and inaccessible a locality.[1] Crude borax is stated by Mr. Calvert[2] to reach Kulu in some quantity from Spiti and Lahul, more probably it comes from Puga, and to be sold at the rate of Rs. 6 for 80 lbs. It is refined at the bazaar at Sultanpur before being despatched to India.

Thibet.—The following information on the subject of Thibetan borax is from a paper by Mr. E. T. Atkinson:[3] "The borax and salt fields of Gnari or Hundes lie to the north of Bongbwa Tal across mountains that round the north-east side of the valley of the Shajan river parallel to the Gangri range, and in the eastern part of the Zjang of Rohtoh (Rudukh), and at the Chapakani lake. The two salts are obtained from different spots in the same vicinity, and are both worked in the same way by lixiviation from the earth taken from the surface of the ground in which the salts are developed by natural efflorescence. These salt-fields are open to all who choose to adventure their labour in them on payment of one-tenth of the produce to the Lhassa Government, who have an excise establishment on the spot. The borax is collected from June to September and sold at the different fairs, at Ganpa, Gartoh, Sibilam, Chajna, Taklakhar, Dabakhar. It is brought down by the Bhotiya traders and purchased by the merchants of Ramnagar, where it is refined. The process is as follows. The borax is pounded and placed in shallow tubes and then covered with water to the extent of a few inches; to this is added a solution of about two pounds of lime dissolved in two parts of water, for every ten maunds (820 pounds) of borax, and the whole mass is well stirred every six hours. Next day it is drained on sieves or cloth, and after this is again dissolved in 2½ times its weight of boiling water, and about 16 pounds of lime added for the above quantity. It is then filtered, evaporation takes place, and subsequently it is crystallized in funnel-shaped vessels, usually of *kansa*, an alloy of copper and zinc or lead. The loss in weight is about 20 per cent."

Saltpetre or Potassium Nitrate: General Remarks.—For a long period the world was dependent for its supply of saltpetre on superficial deposits, the result of a contemporaneous chemical reaction by which the constituents of the mineral were brought into combination with one another. At present there are other sources of supply, such as

[1] Selections from Records, Government of India, Vol. VI, p. 191; and Vol. XIV, p. 38.

[2] Kulu, p. 92.

[3] Economic Mineralogy of the Hill Districts, N. W. P., p. 33.

the natural deposits of potassium sulphate, which have been found in several localities in association with rock salt.

India at one time enjoyed almost a monopoly of the trade, and the supply of Europe was nearly all manufactured in this country. This is explainable by the habits of the people, and the climate which is in some parts of the country very dry for several months after long-continued rain. In the soil of Indian village sites ammoniacal and other nitrogenous waste lies in contact with wood-ash containing potash and possibly also some potash derived from the decomposition of felspar. As oxidation of the nitrogen results in the formation of free nitric acid, combination with the alkaline base follows, and the soil becomes impregnated with saltpetre. By collection of this soil, lixiviation, evaporation, and a simple process of refining which educes other salts, especially the sodium chloride, pure or nearly pure saltpetre is produced. In some cases the collected soil is spread out and exposed to the weather for twelve months or more before being subjected to lixiviation.

Formerly the East India Company had a monopoly of the manufacture, which passed subsequently into the hands of Europeans, and finally, on the decline of the trade, into the hands of natives. More than two-thirds of the total quantity of saltpetre which is exported from Calcutta at present, comes from the districts of Tirhut, Saran and Champaran, in Behar.

The districts of Cawnpur, Ghazipur, Allahabad, and Benares contribute to the supply, as also do some parts of the Punjab.

The following table shows the present condition of the trade[1] :—

	Quantity of Saltpetre exported from Calcutta.	Value.	Price per cwt.		
	Cwt.	£.	£.	s.	d.
1876-77	466,218	381,706	0	16	4½
1877-78	391,373	254,392	0	13	0
1878-79	349,934	301,818	0	17	3
1879-80	463,110	431,814	0	18	7¾

For the year 1868, and for some years previously, the manufacture of saltpetre in the Madura district in Madras was a monopoly in the hands of a European firm, who were under contract to supply the Government with a fixed amount annually. The excess had been exported to England, but latterly this was discontinued in consequence of the prices not being remunerative.[2]

Saltpetre is or was an untaxed industry in the Nellore district. It appears to offer no features of particular interest. The estimated possi-

[1] Report on Administration of Inland Customs, 1879-80, p. 37.
[2] Madura District Manual, p. 25.

ble outturn is 556 maunds, and the selling price was in 1873 Rs. 3 for single refined, and for double refined Rs. 4 a maund.[1] Saltpetre was also manufactured in many other parts of Madras.

There is so much sameness in the mode of occurrence and manufacture of saltpetre all over the country that it would be tiresome and useless to give details in addition to those above quoted under the above general remarks. Most of the local Gazetteers contain abstracts of information on the subject. Formerly, in the Ahmedabad district in Bombay, there used to be a considerable manufacture, but it is now almost extinct, and Behar saltpetre finds its way all over India. In Upper Burma there appears to be a large manufacture and the price realised is high.[2] The references in the Appendix will show where further information on this subject may be obtained.

Potassium Chloride: General Remarks.—In Chapter X it has already been recorded that Dr. Warth discovered in the Mayo salt mines a lenticular band, consisting partly of magnesium sulphate or kieserite, and partly of potassium chloride or sylvine. Altogether only a few maunds of the combined minerals were obtained, and up to the present there has been no further similar discovery.[3]

The following analyses were made Mr. Tween:—

	No. 1. Colourless Salt.	No. 2. Pink-coloured Salt
Potassium chloride	3·8	61·43
Sodium ,,	...	29·32
Magnesium sulphate	58·02	7·78
Potassium ,,	38·	...
Water . .	·62	2·1
	100·44	100·63

from which it would seem that there are two very distinct mixtures of salts having little in common.

[1] Nellore District Manual, p. 67.
[2] Indian Economist, Vol. V, p. 14.
[3] Mem., G. S. I., Vol. XIV, p. 80; and Records, G. S. I., Vol. VII p. 64.

CHAPTER XIII.

SILICA.

ROCK CRYSTAL—General Remarks—Madras—Tanjore—Godavari — Hyderabad — Central Provinces — Sambalpur — Punjab — Gurgaon — Bannu — Mari — Burma. CARNELIAN, AGATE, ONYX, JASPER, &c.—General Remarks—Bengal—Rajmahal Hills—Chutia Nagpur—Central Provinces—Chanda—Bombay—Rewa Kantha. FLINT—General Remarks—Madras—Trichinopoli—Bombay—Dharwar — Afghanistan— Punjab—Bannu. MATERIALS FOR GLASS MANUFACTURE—General Remarks.

Rock Crystal: General Remarks.—It is perhaps scarcely necessary to say very much upon the subject of this well-known mineral; when pure it consists simply of silicic acid. The differently coloured varieties which owe their tints to the presence of small quantities of foreign minerals are called amethyst, rose quartz, false topaz or citrine, smoky quartz, milky quartz, prase, and aventurine quartz.

The range in time of the sources from which rock crystal is obtained is very considerable, but in the older acidic crystalline rocks it is most abundant, being found, however, also in basic traps and basalts and to some extent in sedimentary formations.

The following account of the distribution of quartz crystals in India is far from exhaustive, as only the principal localities of which there are published accounts are mentioned.

Madras: Tanjore District: VELLUM, Lat. 10° 43′; Long. 79° 12.—The lapidaries at Vellum have established a reputation for being skilled workers in different varieties of rock crystal, such as the ordinary pellucid quartz, smoky quartz, cairngorum and amethyst. These are, with the exception of the last, which is brought from Kangiam in Coimbatore, are all derived from the Cuddalur (tertiary) conglomerates, which are made up of the debris of metamorphic rocks.

The ornaments which are made consist chiefly of brooch stones cut in the brilliant, rose, and other patterns, but watch-glasses and double convex spectacle lenses are also made.[1]

Godavari District.—According to Captain Campbell[2] very large prisms of rock crystal used to be obtained in the bed of the Godavari to

[1] Mem., G. S. I., Vol. IV, pp. 217 and 370.
[2] Cal. Jour. Nat. Hist., Vol. II, p. 282.

the west of Rajahmahendri; one which he saw was 5 inches in diameter.

Hyderabad State.—Pellucid rock crystal, rose quartz, and amethyst occur in abundance in the quartz reefs in many parts of Hyderabad, and, according to Dr. Walker, they used to be cut into beads and stones for rings, the value being about the same as that of the garnet.

Central Provinces : Sambalpur District.—BIJKOMAR, Lat. 20° 40′; Long. 83° 31′.—At this locality and others in the same region, fine quartz crystals, both the smoke and pellucid varieties, are obtainable, and good samples are now in the Geological Museum, but there is no attempt to work these crystals, and they have no local value.[1]

Punjab: Gurgaon District: AURANGPUR, Lat. 28° 27′ 30″; Long. 77° 19′.—At this locality, which is 15 miles south of Delhi, there are small pits which Mr. Hacket[2] states were for the purpose of extracting quartz crystals from veins of quartz in the Arvali quartzites. These pits are now abandoned, but small rejected crystals are scattered over the surface in great abundance.

Whether this was the source whence the material was obtained from which the marvellous Delhi rock crystal ornaments were made is not known. At the loot of the Delhi palace a number of vases, pitchers, drinking vessels, &c., sculptured out of transparent quartz crystal, were obtained, and a series of them, purchased by Mr. W. Theobald, was presented to the Geological Museum.

Bannu and Mari, &c.—As has been mentioned in the description of the gypsum deposits of this province, small bi-pyramidally terminated prisms of quartz, which commonly go by the name of Mari diamonds, are obtained in the gypsum at Kalabagh, Sardih, and Mari. They are collected by the natives, bored and threaded for chains. In Kulu, according to Mr. J. Calvert, good-sized quartz crystals have been found on the north side of the Kanor Khud opposite the silver mine.

Burma.—The Reverend F. Mason states that small crystals of quartz are abundant in Burma, and large masses of rock crystal are sometimes brought from the Siamese frontier. Many of the so-called rubies and other precious stones offered for sale by the Shans are said to be quartz which has been coloured by treatment in various solutions.

Carnelian, Agate, Onyx, Jasper, &c.: General Remarks.—In the above heading jasper is included as matter of convenience, being rather a rock of undefined composition than a mineral species. Car-

[1] Records, G. S. I., Vol. X, p. 183.
[2] *Idem*, Vol. XIII, p. 250.

nelian, agate, and onyx, with several other varieties, belong to the chalcedonic group of massive, non-crystalline forms of translucent silica. The chief original sources of these varieties are the enormous flows of Deccan trap which cover over such a large area of India. In trap rocks of other ages, too, they are found in some abundance.

Though none of these exactly come under the denomination of precious stones, still, when wrought into ornamental objects, they have sometimes commanded very high prices. In the arts of cutting and polishing them the lapidaries of India have long been renowned,—for so long indeed that some of the very earliest allusions to the country are connected with this particular art. It is probable that the polished and cut pebbles of India have been spread over the world to an extent of which few people conscious. It is said that the pebbles which the tourist or visitor is induced to buy at many well-known seaside and other resorts in Europe, as mementos of the place, have not only been originally produced but have been cut and polished in India. If it be so, the trade is a more creditable one than that which sends sham jewels to Ceylon, because the stones are really what they pretend to be, true pebbles, and they are often extremely beautiful objects. It has sometimes been thought that in the name brooch the source of the pebbles which were first employed for the purpose is recorded, but the derivation is said to be from the French *broche*, a spit or skewer. From Barygaza, the modern Broach, the famous onyx and murrhine cups of the early Greeks and Romans were obtained, it is believed.

Nero is said to have paid 300 talents or £55,125 for one of the small cups made of the murrhine or carnelian (?), which was probably not very different in any respect from those to be obtained in Bombay at the present day. According to Professor Müller,[1] however, 600 writers have emulated with one another in attempting to decide what the *murrha* of the ancients really was, and his judicial decision is that it was fluor spar. But if obtained at Ouzein, the modern Oujein, it is extremely improbable that it was other than one of the chalcedonic minerals. In none of the accounts is fluor spar mentioned as one of the stones which is worked in Western India, and it has been shown in Chapter XI that the occurrence of the mineral in India is very rare, there being no known locality where more than mere traces of it are found. In Chapter I it has already been suggested that the so-called copper-coloured diamonds of early Sanscrit authors were really carnelians. A Roman traveller in 1503, named Lewes Uertomenes, speaks of the diamond however, as well as onyx and carnelian

[1] Commerce and Navigation of the Erythican Sea. J. W. McCrindle, p. 35.

being obtained in this region. The Panassa of Ptolomey, which has been supposed by some writers to have been Panna, was possibly Ponassa, in the Narbada valley. . .

It may be added that in the habit which has grown up of writing this word cornelian the original derivation has become lost and obscured; the word is from *carnis*, flesh, in allusion to the colour.

Hyderabad: PAITHAN, Lat. 19° 29′; Long. 75° 28′.—According to the author of the Periplus, Plithana was one of the localities from whence agate and onyx were obtained for the factories at Broach. It is believed that Plithana may safely be identified with Paithan, or, as it is sometimes written on old maps, Peyton, on the Godavari.

In this neighbourhood there are ossiferous gravels in which not only have bones of mammals been discovered, but an agate flake, believed to be of human manufacture, was found there *in situ* by Mr. Wynne.[1]

The pebbles in these gravels are chiefly of agate, and it was noticed by Mr. W. T. Blanford[2] that many of them have a peculiar dark, semi-transparent look resembling flint, and are different in this respect from those found in the neighbouring trap.

There are many other localities in the trappean region of Hyderabad where agates occur and have been worked. Newbold [3] gives a very full list of these localities and the varieties of pebbles which occur at them respectively. He particularly mentions the beds of the Kistna, Godavari and Bhima rivers and the plain at Bijapur.

Bengal: Rajmahal Hills.—Geodes of quartz crystals and masses of agate are found in some abundance weathered out of the trap of liassic age, which occurs in these hills, but the natives appear to be wholly indifferent to the fact, and there do not appear to have ever been any lapidaries in the neighbourhood to work the stones up into saleable articles. Very handsome masses of these minerals, of large size and suitable for the ornamentation of pleasure-grounds, rockeries, &c., are to be obtained for the trouble of carriage in the neighbourhood of Barhait, &c., in the centre of the hills.

Chutia Nagpur.—The submetamorphic or transition rocks of the southern districts of this province often include banded jaspers of some beauty; fragments of these two occur as pebbles in several of the streams in Singhbhum and the Native States further south.

In the Palamow sub-division, the bed of the Sone has long been famed, being mentioned in the 'Ain-i-Akbari' for yielding pebbles (Saligram).

[1] Records, G. S. I., Vol. I, p. 65.
[2] *Idem*, p. 61.
[3] Jour. Roy. As. Socy., XX., p. 37.

These are only occasionally collected as curiosities at the present day. Some of the pebbles, especially those of agate, have probably been derived from far-distant trappean sources; others may have come from the transition rocks.

Central Provinces: Jabalpur District.—Although agate pebbles are known to be very abundant in the debris from the trappean rocks, and, it is believed, afford one source from whence the lapidaries of Jabalpur obtain material for their ornamental stonework, which is remarkably cheap and often very beautiful, still there does not appear to have been very much published on the subject. Some of the stones from the Ratanpur mines, which are described on a subsequent page, are said to be taken to Jabalpur to be cut, while the true or Sulemani onyx goes to Cambay from Jabalpur. It would be interesting to know from whence the aventurine quartz comes which is sometimes to be seen for sale. The imitation of this stone, now made in Venice, is so good that it requires an expert to distinguish the true from the false.

Chanda District: BALLAPUR, Lat. 29° 41′; Long. 79° 24′.—This place, which is 6 miles south of Chanda and is on the left bank of the Wardha, was an early capital of the Gond kings. According to the 'Ain-i-Akbari'[1] it was at one time famous for producing agate pebbles.

Bombay: Rewa Kantha District: RATANPUR.—This place, which is situated in the territories of the Raja of Rajpipla, has for upwards of 2,000 years been one of the principal adjacent sources from whence the lapidaries of Cambay and Broach have drawn the raw materials from which they manufactured ornamental articles of agate, carnelian, &c. But besides it there were, as will be seen, many other localities at more distant points which contributed special varieties.

Although agate, carnelian, and jasper may be picked up in the rivers adjoining the trap area, and are to some extent collected, the stones which are most highly esteemed are all obtained, according to Mr. W. T. Blanford,[2] in a thin stratum of ferruginous tertiary gravel, which consists almost entirely of agates derived from the trap. This preference is probably due to the presence of the iron, which gives to the stones the colouring matter which determines their value.

The following account of the mining and working up of the stones is taken from the Bombay Gazetteer *verbatim*, as it contains the most complete account, and it would be hardly fair to the author, Mr. J. M. Campbell, to give a mere abstract of it:—

[1] Gladwin's Editions, Vol. II, p. 58.
[2] Mem., G. S. I., Vol. VI, p. 381.

"The mine shafts are about 4 feet in diameter, and on an average about 30 feet deep. At the foot of each shaft, galleries 5 feet high and 4 feet wide branch off on all sides. These passages, seldom more than 100 yards long, in many cases join the galleries of other mines, Every mine has a band of thirteen men, each with a small iron pickaxe, a few bamboo baskets and a rope. They work in turns, and before he is relieved each man must fill a certain number of baskets. The basket is drawn up by a rude roller or pully supported by four uprights. At the mine mouth the stones are chipped, and the likely ones carried to Ratanpur, the village of gems, and there made over to the contractor or his agent. The average outturn of two men, working from eight to ten hours, is from ten to forty pounds weight of stones.

"The contractor divides the stones into two classes, those which should and those which should not be baked. Three stones are left unbaked: an onyx called *mora* or *bawa ghori*, the cats'-eye called *cheshamdar* or *dola*, and a yellow half-clear pebble called *rori* or *lasania*. Of these the *mora* or *bawa ghori* onyx[1] is of two kinds, one dark with white veins, the other greyish-white with dark veins. These stones are found in different shapes, and are seldom more than one pound in weight. Except these three varieties, all Ratanpur pebbles are baked to bring out their colours. During the hot season, generally in March and April, the stones are spread in the sun in an open field. Then in May a trench, 2 feet deep by 3 wide, is dug round the field. The pebbles are gathered into earthen pots, which, with their mouths downwards and a hole broken in their bottoms, are set in a row in the trench. Round the pots goat and cowdung cakes are piled, and the whole is kept burning from sunset to sunrise. Then the pots are taken out, the stones examined, and the good ones stowed in bags. About the end of May the bags are carted to the Narbada and floated to Broach. Here they are shipped in large vessels for Cambay, and are offered for sale to the carnelian dealers. The right of working the Rajpipla mines is every year put up to auction. It would of late seem to have become more valuable, as the average for the last four years (1873-76) has been £323, (Rs. 3,230), compared with £189 (Rs. 1,890) in the twenty previous years. The contractors are generally Baroda and Cambay merchants, Vanias and Bohoras by caste.

"By exposure to sun and fire, among browns the light shades brighten into white, and the darker deepen into chesnut. Of yellows, maize gains a rosy tint, orange is intensified into red, and an intermediate shade of yellow becomes pinkish-purple. Pebbles in which cloudy browns and yellows were at first mixed are now marked by clear bands of white and red. The hue of the red carnelian varies from the palest flesh to the deepest blood-red. The best are a deep clear and even red, free from cracks, flaws, or veins. The larger and thicker the stone, the more it is

esteemed. White carnelians are scarce. When large, thick, even-coloured, and free from flaws they are valuable. Yellow and variegated stones are worth little.

"Four agates, the common, the moss, the Kapadvanj, and the veined, rank next to the Rajpipla carnelians. The common agate is of two kinds, a white half-clear stone called *dola* or *cheshamdar*, and a cloudy or streaked stone called *jamo*. The colour varies, but is generally a greyish-white. Both kinds come from north-east Kattywar near Mahedpur in Morvi, 3 miles from Tankara. Of the stones, which lie in massive blocks near the surface, the most perfect do not exceed five pounds in weight, while those of inferior quality, in many cases cracked, weigh as much as sixty pounds. These stones are brought to the Cambay dealers by merchants, who, paying a royalty to the Morvi chief, hire labourers, generally Kolis, to gather them. When worked up, the common agate is a greyish-white, and being hard, brittle, and massive, it takes a high polish.

"Like the common agate, the moss agate, *suabhaji*, comes from Bud-Kotra, 3 miles from Tankara in Morvi. Found in the plain about 2 feet under the surface in massive layers often cracked, and from half a pound to forty pounds in weight, they are gathered in the same way as the common agate. When worked up, they take a fine polish, showing, on a base of crystal, sometimes clear, sometimes clouded, tracings as of dark-green or red-brown moss.

"Besides from the town of Kapadvanj in Kaira, where, as its name shows, the Kapadvanj agate is chiefly found, this stone is brought from the bed of the river Majam, between the villages of Amliyara and Mandva, about 15 miles from Kapadvanj. It is found on the banks and in the beds of rivers, in round kidney and almond-shaped balls from half a pound to ten pounds in weight. Picked up by Bhils, they are sold to a Mandva Bohora, who disposes of them to the Cambay stone-merchants at from 6*s.* to 24*s.* for forty pounds (Rs. 3-12 a *maund*). When worked up the Kapadvanj agate takes a high polish. It varies much in colour and pattern. In some cases they are variegated; in others they have forms of finely-marked plans grouped into landscape and other views. The trade names of the chief varieties are *khaiyu*, *agiyu*, and *ratadiyu*.

"The most valued Cambay agate, the veined agate, *doradar*, comes from Ranpur in Ahmedabad. Found near the surface in pebbles of various shapes, not more than half a pound in weight, they are gathered in the same way as moss agates, and when worked up take a high polish, showing either a dark ground with white streaks, or dark veins on a light background.

"Of other Cambay stones the chief are the jasper or bloodstone, the chocolate stone, a variegated pebble known as *maimariam*, crystal, the lapis-lazuli or azure stone, the obsidian or jet, and the blue-stone, *piroja*.

Of these the first four are found in Guzerat. The rest are foreign stones brought from Bombay. The jasper, heliotrope, or bloodstone comes from the village of Tankara in Morvi, about 20 miles north of Rajkot; found on and near the foot of Bhag hill, in massive layers of from half a pound to forty pounds, it is gathered in the same way as the agate. When worked up it takes a high polish, varying in colour from *lila chhantdar*, a green variety with red streaks or spots, to the finer *patolia*, whose green base is more equally mixed with red and yellow. The chocolate stone, *rathia*, comes from Tankara in Morvi; found on the surface, or a few feet under ground, in masses of from one to eight pounds, it is too soft and earthy to take a high polish. *Maimariam* is a liver-brown, marbled with yellowish marks of shells and animalculœ. Dug in blocks of considerable size at Dhokavada on the Ran of Cutch, about 60 miles north of Deesa, it is too soft to take a high polish. Cambay crystal, *phatak*, comes from Tankara in Morvi, where it is found in masses of from one to twenty pounds. As clear as glass it takes a high polish. The best Cambay crystal comes from Madras, Ceylon, and China. Lapis-lazuli, or azure stone, *rajavarat*, is deep-blue with a sprinkling of silvery or golden spots; a foreign stone coming to Cambay through Bombay, it is found in rounded balls in Persian and Bokharan river-beds. It is too soft and earthy to take a high polish. Jet, or black stone, *kala phatar*, is also foreign coming through Bombay from the hills of Bassora and Aden, where it is found in large blocks. Like glass in fracture, it is not very heavy, and takes a high polish (it is probably obsidian). The Cambay jet trade has almost entirely ceased. The Cambay blue-stone is not the true *piroja* or turquois, but a composition imported from China in flat pieces of not more than half a pound in weight. Like blue glass in appearance, though soft, it takes a good polish.

"The rough stone generally passes through three processes, sawing, chiselling, and polishing. When a stone is to be sawn it is brought to a strong frame of two wooden uprights, joined at the foot by a cross-board, and at the top by a strong rope doubled and tightened by a stick. The stone is then laid on the cross-board, and fixed firmly to it by a cement of coarse bees'-wax and cloth fibres. The saw, a slight toothless iron plate in a light wooden frame, is then brought up, and, according to the size of the stone, is worked by one or two men. To smooth its freshly-cut faces, a mixture of ground emery, fine sand, and water, is kept dropping into the cleft in which the saw works. To chisel it into shape the stone is taken to a slanting iron spike, *khondia*, driven into the ground till only the head is left above the surface. Laying against the edge of this spike the part of the stone to be broken off, the workman strikes with a horn-headed hammer till all roughness has been removed. The article is now handed over to the polisher. He takes it to a platform 16 inches long by 6 broad and 3 thick. In this platform are two strong uprights, and between

the uprights a wooden roller, 8 inches long and 3 in diameter, fastened into a head at one end. This roller works on an iron spindle or axle. On the one end, the axle is screwed and fitted with a nut to which certain plates or discs can be made fast. These grinding or polishing plates are made of emery mixed with seed lac. The emery, *karanj*, of greyish-black, is carefully powdered and glistening. The preparation of emery varies in fineness according to the nature of the work. For rough work the proportion is three parts of ground emery to one of lac; for medium work the proportion is two and a half pounds of finely powdered emery to one of lac; and, for the finest work, lac and carnelian dust, *vari*, are used in equal quantities. Besides the composition plates a copper disc is occasionally used for polishing very hard stone, such as Ceylon cats'-eyes and other precious stones, and for the softer sort of pebbles, a plate of teak or other close-grained wood is used. Fastening in its place on the roller the disc best suited to the stone to be polished, the workman, squatting on his hams, steadies the machine with his foot. A bow, with its string passed round the wooden roller, is held in his right hand, and by moving the bow backwards and forwards, the roller and with it the polishing plate is whirled round, while the article to be polished is held in the workman's left hand, and as it revolves is pressed against the outer face of the polishing disc.

"Besides these three regular processes, certain articles require special treatment. After beads have been chiselled into shape, to smooth their surface, a number are fixed in a pair of wooden or bamboo clamps, and rubbed on a coarse and hard smoothing stone called *dholia*. Next they are grasped in a grooved clamp, and rubbed along a wooden polishing board called *patimar*. The surface of this board is cut into grooves, and roughened by a composition of emery and seed lac. To give beads their final brilliancy, from one to several thousands of them, are, along with emery dust and fine carnelian powder, thrown into a strong leather bag, about 2 feet long and from 10 to 12 inches across. The mouth of the bag is tied, and a flat leather thong is passed round its centre. Seated at opposite ends of a room, two men, each holding one end of this leather thong, drag the bag backwards and forwards. This rolling lasts from ten to fifteen days, and during the whole time the bag is kept moistened with water. When the polishing is complete, the beads are handed over to have holes bored. This is done by a diamond-tipped steel drill, and as the drill works water is dropped into the hole through a thin narrow reed or metal tube. Cut beads are polished on the wheel as well as rubbed on the smoothing stone, and knife-handles are prepared in the same way as cut beads. In making cups, saucers, and other hollow articles, the outside is first chiselled into shape and ground on the smoothing stone. To hollow the inside, the diamond-tipped drill is worked to the depth of the fourth of an inch all over the space, till the surface is honeycombed with

drill holes. The prominent places round these holes are then chipped away till a hollow of the desired depth has been formed. The inside is then polished on a convex mould, of the same composition as the polishing plates, and like them fastened to the polishing wheel. Miniature cannons are bored by diamond-tipped drills. A small headed drill is first worked, and then the number of diamonds on the head is gradually increased from two to a circle of twelve. Flat ornaments, such as paper-cutters, paper-weights and ornamental slabs, are cut into layers of the required thickness by the toothless saw.

"Cambay agate ornaments belong to three classes: those suited for the Chinese, the Arab, and the European markets.[1] For the Chinese market, carnelian ornaments only are in demand. Of these there are two kinds, flat stones named *muglaigul*, and beads called *dol*. The flat stones, oval, square, and like watch seals, are worn in China as armlets and dress ornaments. Plain polished round beads are made into necklaces of fifty stones each. For the Arab markets, the stones most in demand are Ranpur agates, Ratanpur carnelians, cats'-eyes, and bloodstone.[2] These are wrought into both plain and ornamental ring stones, necklaces, wristlets, and armlets. Of necklaces there are those made of cut beads, *peludar dol;* of diamond-cut beads, *gokhendar dol;* of almond-shaped beads, *badami dol;* and of spearhead-shaped beads, *chamkali dol*. Again, there are necklaces of three stones called *madalia* or *tavit*, and of plain round beads used as rosaries as well as necklaces.[3] Of armlets and wristlets there are those of two stones, *mota madalia*, worn either on the arm or wrist; wristlets of seven round flat stones, *patia;* wristlets of several flat stones, *ponchi;* armlets of one stone cut into different fanciful devices, *baju;* and single stones in the shape of large flat seals, *nimgol*. Rings, *anguthi*, and stones for setting as rings, *nagina*, are also made of carnelian and cats'-eyes. For the European markets, the ornaments most in demand are models of cannon with carriage and trappings, slabs for boxes or square tables, cups and saucers, chessman, flower-vases, pen-racks, card and letter racks, watch-stands, inkstands, knife-handles, rulers, paper-cutters, penholders, necklaces, bracelets, brooches, paper-weights, crochet needles, silk winders, marbles, brace and shirt studs, seals, and rough stones polished on one side. Within the last thirty years (1851), part of the trade with Arabia lay through Veraval in South-west Kattywar. At present (1878), except a very small supply for the Sind and Kabul markets taken by the horse-dealers and other Afghans who visit Cambay, the whole produce is bought by

[1] In 1787, seal-shaped stones went to Europe and Arabia, pearl-shaped stones as big as a pistol ball to China, and octagons to the Guinea Coast and Mozambique. Hove's Towes: Bombay Government Selections, XVI, 49.

[2] Jet ornaments were formerly (1851) exported to Arabia; of late years the trade has ceased.

[3] The demand for necklaces of oblong flat beads, *katli*, is said to have ceased.

Bombay merchants, chiefly of the Bohora caste, and by them sent from Bombay to China, Arabia, and Europe.

"According to the latest details, the trade in Cambay stones at present supports about 600 families of skilled workmen, and from 500 to 600 unskilled labourers. The skilled workmen are all Kanbis, the labourers Musalmans and Kolis. The whole body of skilled workmen includes four distinct classes, each engaged on a separate process. Compared with the 1850 returns, the figures for 1878 show a fall from 200 to 100 in the number of polishers on the rough stone, *dolias*. On the other hand, the workers on the lapidaries' wheel, *ghasias*, have remained steady at 300; the drillers, *vindhars*, and the polishers on the wooden frame, *patimars*, at 50.[1]

"Each process is carried on in a distinct workshop. At the head of each workshop, *karkhana*, is a well-to-do Kanbi known as the *karkhanawala*, or head of the factory. This headman, though generally not above working with his own hands, has under him, besides a varying number of labourers, from two to ten skilled workers. The skilled workers, all grown men, as women and children do not help, receive monthly wages, each according to the work he has done; the unskilled labourers, many of them boys, are paid by the day or as their services are wanted. From the richest of the workshop heads, the highest class of agate workers, the agate dealers, *akikias*, are recruited. The *akikia*, who must be a man of some capital, buys the stones as they come rough into the Cambay market. In his factory the rough stones are sawn and chiselled, and then, according to the nature of the stone and the use to which it is to be put, he hands it over to the headman of one of the polishing factories. When the work is completed, the Cambay dealer disposes of the finished articles to the agate merchants of Bombay, or sends them through Bombay to Calcutta, China, or Jedda. According to the returns, the number of agate dealers, *akikias*, in Cambay has, during the last twenty-five years, fallen from 100 to 50.

"In each branch of the craft the heads of factories form a distinct guild or *panchayat*. There is the guild of polishers on stone, *dolia panchayat;* of polishers on wood, *patimar panchayat;* of workers on the lapidaries' wheel, *ghasia panchayat;* and of drillers, *vindhar panchayat*. Above them is the dealers' guild, *akikia panchayat*, in whose factories the work of sawing and chiselling is carried on. Over each of these guilds a headman, chosen by

[1] Within the last thirty years about 167 families of agate workers have abandoned their craft. Of these, 7 have gone to Ahmedabad; 10 to Baroda; 25 to Bombay; and 125 have become cultivators in Cambay. Those in Ahmedabad have taken to silk-weaving; those in Baroda to tobacco-selling, polishing precious stones and weaving; those in Bombay to stone-polishing and glass-mending. The Bombay settlers still keep up their connection with Cambay, going there for marriage and death ceremonies. They have also, both publicly and in their houses, shrines representing the tomb of the founder of their craft. (These and some of the particulars about the trade unions have been obtained from one of the Kanbis settled in Bombay.)

the votes of the members, presides. There is no combination among the workers in the different factories, and there is no record of any dispute between the workers and their employers. Any skilled worker, who raises himself to be head of a factory, may become a member of the guild of the branch of the craft to which he belongs. On joining a guild the new-comer is expected to give a feast to the members, the expense varying from £17 10*s*. to £80 (Rs. 175–800). He is at the same time required to pay the Nawab a fee of from £1 10*s*. to £10 (Rs. 15–100).[1] From time to time the members of a guild hold a feast, meeting the charges out of the common funds. In any factory, if one of the skilled workers wishes to have a son taught the craft, or if a new hand is anxious to join, he gives a dinner to the head of the workshop and to the other skilled workers. Except in making arrangements for the unpaid service due to the Nawab, the trade funds would seem to be applied to no purpose but that of entertaining the members. When a guild feast is held, if one of its members chances to be sick, his share of the dinner is sent him. With this exception, the practice of using trade funds to support the sick or those out of work, or to provide for widows and orphans, is unknown.

"On paying the Nawab a fee, and agreeing to meet the customary charges, including a yearly subscription of £1 4*s*. (Rs. 12), any member of one of the under-guilds may become a dealer, *akikia*. About four years ago, the heavy cost of joining the *akikia* guild caused a dispute. Certain of the polishers, *ghasias*, claimed the right to deal in stones without becoming members of the *akikia* guild. The regular dealers were too strong for them, and failing to get any business, they were forced to leave Cambay. With some families of drillers they retired to Ahmedabad. But finding themselves no better off there, they returned to Cambay.

"The guilds are useful in arranging for the service due to the Nawab. When the Nawab wants a lapidary, he tells the dealers' guild what work he wishes done. The chief of the dealers sends to the master of one workshop in each branch of the craft, telling him what is wanted, and asking him if he will undertake the duty. If he agrees,—and there is generally in each class one master-worker who undertakes the Nawab's orders,—he receives from £5 to £6 (Rs. 50–60) from the guild funds. Among guild rules, one forbids master-workers engaging the services of workmen belonging to another factory. Another lays down certain days, amounting in all to about two months in the year, to be kept as holidays. Breaches of the rules are punished by fines varying from 2*s*. 6*d*. to 5*s*. (Rs. $1\frac{1}{4}$-$2\frac{1}{2}$)."

[1] Some years ago the details were, to join the *dolia* guild, £19 (£17 10*s*. in dinners and £1 10 *s*. for the Nawab); to join the *ghasia* guild, £37 (£35 in dinners and £2 for the Nawab); to join the *patimar* guild £15 (£12 10*s*. in dinners and £2 10*s*. for the Nawab); and to join the *akikia* guild, £90 (£80 in dinners and £10 for the Nawab). At present (1876) a fee is paid to the Nawab only on joining the *akikia* guild.

For an interesting sketch of the early history of this trade, reference may be made to the Bombay Gazetteer, Vol. VI, p. 205.

The actual value of the trade is less extensive than may have been concluded from the above; in 1805 it was estimated at Rs. 62,230; in 1843 Rs. 94,900; and the returns for the five years ending 1878 give an average of Rs. 70,000.

Malwa: Ujein, Lat. 23° 10′; Long. 74° 47′.—There is, as already stated on page 504, a geological difficulty about accepting the view expressed by Professor Müller that the material of the murrhine cup was fluor spar; if it was obtained at Ujein or Ouzein, or any other locality within the trappean area, it was almost certain to have been one of the chalcedonic minerals, *viz.*, carnelian or agate. Fluor spar is not known to occur in the trap.

Some notices of carved antique gems obtained in Afghanistan, of which carnelian appears to have been the favourite material, will be found in the papers noted below.[1]

Flint: General Remarks.—Flint is a massive compact form of silica, and is generally of dark colour. It breaks with sharp-cutting edges and a conchoidal surface. The chief distinction between flint and hornstone is that the latter is more brittle, and does not work so easily; chert is an impure hornstone which occurs in bands in limestones.

True flints are of rare occurrence in India, but hornstones, agates, &c., have been largely employed in prehistoric times in the manufacture of the knives, &c., which generally go by the name of flint implements, and some of them afford substitutes for gun-flints and flint and steel.

Madras: Trichinopoli District.—Flints, almost undistinguishable from English chalk flints, are found at Coorchycolum, a few miles south of Vellur and to the south-east of Sainthoray. They are believed to exist as a continuous band, not in detached nodules in the highest cretaceous beds, but were not seen *in situ*, though shattered fragments abound on the surface at the localities above indicated.[2]

Gun-flints are said to be obtainable in the Bellary district, but the nature of the source is not known.[3]

Bombay: Dharwar District: Wodoorti, about 2 miles south of the manganese locality (see page 331). At the above-named place, Captain Newbold[4] states there were pits, from whence Hyder and Tipu obtained supplies of gun-flints for their troops. "They are of a yellowish-brown

[1] Jour. As. Soc. Bengal, Vol. IX, pp. 97-100; Vol. X, p. 613; Vol. XI, p. 316.
[2] Blanford, H. F. Mem., G. S. I., Vol. IV, p. 213.
[3] District Manual, p. 95.
[4] Madras Journal of Lit. and Sci., Vol. XI, p. 46.

colour, translucent at the edges, tough, of a jaspery nature, and answer the purpose, it is said, extremely well."

Afghanistan.—Immediately across the Kurram on the Afghan side opposite to Thal, there is a source of flint much resorted to by the Yagi tribes for gun-flints. Mr. Wynne[1] has described it as a rugged hill called Bakkarkanch (flint-stone), which is formed of masses of altered brecciated beds, some being altered limestone or a siliceous rock full of angular fragments of hornstone or flint usually mottled or banded with reddish or dark, purple and gray tints.

Punjab: Bannu District.—Flints, obtained from the nummulitic limestones, of this district were exhibited at the Lahore exhibition.[2]

Materials for Glass Manufacture: General Remarks.—This would hardly be a suitable place for describing the native processes of glass manufacture. Already it will have been seen that India abounds in materials suited for the manufacture of glass. The simplest material is afforded by the collection of reh, which contains soda in the form of carbonate. The natural impurity consists largely of silica, so that when melted a coarse glass is produced, from which the women's bracelets, called *churis*, are manufactured. In many parts of the country the natives are perfectly well aware of the existence of suitable materials, and the reason that the manufactured glass is not of better quality is that the furnaces are on too petty a scale, and the heat is not sufficient to properly melt the whole mass of the material; the glass is often spotted or full of air bubbles; but there is good reason for belief that under skilled guidance the natives of India would become admirable workers in glass.

For information as to the practice of glass-making in India reference should be made to the works noted below.[3]

[1] Records, G. S. I., Vol. XII, p. 111.

[2] Punjab Products, p. 45.

[3] Heyne. Tracts, p. 355. Baden-Powell. Punjab Manufactures. Balfour. Cyclopædia, Art.—Glass.

CHAPTER XIV.

BISILICATES, UNISILICATES AND SUBSILICATES.

JADE OR NEPHRITE—General Remarks. JADEITE—General Remarks—Bengal—Mirzapur—Turkistan—Upper Burma. ASBESTOS OR AMIANTHUS—General Remarks—Madras—Salem — Mysore—Bengal — Chutia Nagpur — Afghanistan — Punjab — Garhwal. BERYL OR EMERALD—General Remarks—Madras—Coimbatore— Bengal— Hazaribagh—Rajputana—Panjab—Burma. GARNET—General Remarks—Madras—Nellore—Godavari—Vizagapatam—Hyderabad — Bengal — Chutia Nagpur — Hazaribagh — Central Provinces—Rajputana — Kishengarh — Jaipur — Udepur—Burma. ZIRCON—General Remarks. IOLITE OR DICHROITE — General Remarks. MICA — General Remarks — Madras — Vizagapatam — Bengal — Hazaribagh— Behar—Gya—Central Provinces—Balaghat—Bombay—Rewa-Kanta. LAPIS LAZULI —General Remarks — Badakshan. KYANITE—General Remarks. TOPAZ—General Remarks.

Jade: General Remarks.—Under the name jade several different minerals are included; being applied to similar purposes, they are not always easily distinguishable.

Nephrite jade is a variety of the hornblende group; being nearly allied to tremolite in composition, it is a lime and magnesium silicate. The name nephrite is derived from the Greek νεφρος, the mineral having been supposed to be a specific in diseases of the kidney. It is used for carvings in Burma, China, and New Zealand, but in China jadeite is more highly esteemed, while much of what is sold as jade is really prehnite (a lime and aluminium silicate). Serpentine is also sometimes passed off as jade, not to mention very clever imitations in glass, of which examples are to be seen in the bazaars of Burma, and apparently also in those of Central Asia. Some samples of the latter, brought from Kashgarh, were supposed to be of Russian manufacture, but they may have come from China.

Jadeite: General Remarks.—This mineral belongs to the epidote group, and has a more complicated composition than nephrite, including a number of bases combined with silica. It is used for ornamental purposes in China and some ornaments found in the ancient Swiss Lake-dwellings are said to have been of this material. It is to be understood that information is incomplete as to which of the above minerals some of the jades mentioned in the following remarks should respectively be referred.

Bengal : Mirzapur District.—In this district Mr. Mallet[1] mentions that the hornblende rock west of Dumrahur and Urjhut, owing to its light-gray colour would be more appropriately called tremolite, and that in places it passes into the condition of jade. In this form it is met with between Kotamowa and Bumnee (Bhamni), and at the top of the Kurea Ghât, where bands from one foot to several feet in thickness are interbedded with mica-schist; an olive-green jade occurs north-west of Kisari, and jade is also found associated with the corundum at Pipra (*vide* Chapter IX).

Turkistan : Karakash.—Though beyond our limits, it will not be otherwise unsuitable to introduce here a short notice of the jade mines of the Kuenlun range, since they have been visited and described by a former officer of the Geological Survey of India, the late Dr. F. Stoliczka.[2] The Karakash mines are situated about 17 miles from Shahidula, in a south-westernly direction. The actual mines, which are shallow pits with short galleries at the bottom, are very numerous, and at a distance look like pigeon-holes on the side of the hill. The principal rocks with which the jade-bearing veins occur are syenitic gneisses with micaceous and hornblendic schists.

The jade is associated in the veins with a white crystalline mineral, the nature of which was not determined. As it was not affected by the blow-pipe, it cannot have been a zeolite as was suggested. It seems possible that it may have been a dolomite, as it is said to have been coarsely crystalline, and to have exhibited rhombohedral faces on a fresh fracture. The jade varied in colour from pale green to a dark green like the colour of ordinary serpentine. The pale green was the most common; there was also some white jade. The translucent green variety was rare, only occurring in thin veins, and was often full of flaws. Some of the veins of pale-green jade were 10 feet thick, the hardness was about equal to that of common felspar or below 7. These mines, it is believed, have been worked by the Chinese for many centuries, but had been abandoned when they were driven out of Yarkand in 1864. It is not improbable that working them has been resumed since the Chinese have again taken possession of the country.

As fragments of jade are to be seen in most of the streams from the Kuenlun range, it is believed that the veins have a wide extension; but the superficial covering on the rocks makes it difficult to trace them out. Somewhere south of Kotan, there are other mines of great antiquity, which were mentioned as producing jade by Chinese authors who wrote

[1] Records, G. S. I., Vol. VII, p. 51.
[2] *Op. cit.*, Vol. V, p. 22.

2,000 years ago. For many centuries a system of dredging the rivers of Kotan for jade has been in practice. The name for jade is *zu* in Chinese, *kash* in Eastern Turkistani, and *yashm* in Persian.[1]

By some authorities however the *zu* of the Chinese has been identified with jasper, and Mr. Prinsep[2] considered that *zu* was green quartz or prase.

Upper Burma.—From a very complete *résumé* of the available information regarding the jade mines of Upper Burma by Dr. J. Anderson,[3] we learn that the mines are in the Mogoung district, 25 miles to the south-west of Meinkhum. The pits do not exceed 20 feet in depth, and the jade is described as occurring in loose boulders. Sometimes 1,000 men, Shans, Chinese, Panthays, and Kakhyens, used to be engaged in digging. There used to be a large trade in the mineral, much of it going to Momein, where it was manufactured into ornaments.

At Bhamo, Dr. Anderson bought rings of jade for Rs. 4 each of the quality which at Canton would sell for £2. Taxes are laid on the industry at all stages, and in 1836 the annual revenue derived from it was Rs. 40,000.

At Momein a pair of bracelets of the finest jade cost about Rs. 100. Dr. Anderson describes the method of cutting the jade by means of circular discs of copper which are charged with silicous mud and what appeared to be ruby-dust. The most valuable jade is of an intense bright-green colour resembling the emerald, but red and pale pinkish kinds are also highly prized.

Asbestos or Amianthus.—The term asbestos is applied to fibrous varieties of several different minerals. Strictly speaking, it ought perhaps to be restricted to those of the hornblende series, but sometimes a pyroxenic or augitic asbestos is met with. For the fibrous varieties of serpentine the term chrysotile should be used. Amianthus is sometimes applied to them, but this term is also more properly applicable to fibrous varieties of hornblende.

Many of the uses to which asbestos are put are well known, and its properties as a refractory fire-resisting substance secured its employment for special purposes, even by the nations of antiquity. The number of useful purposes to which this incombustible, non-conducting, and at the same time pliable material can be put is constantly increasing. Among the most recent and important of these additions, the preparation of a

[1] *Conf.* Col. Yule's Marco Polo, Vol. I, p. 177.
[2] Jour. As. Soc. Bengal, Vol. VI, p. 265.
[3] Expedition to Yunan, p. 66.

rope which is used for packing steam-pipes, and a paper board or felt, for the junctions of steam-pipes, may especially be mentioned.

In India, though asbestos has been observed and collected at many widely separated localities, both in the peninsula and in the extra-peninsular countries, it remains still to be shown whether it is anywhere sufficiently abundant to be of commercial value.

Madras: Salem District and Mysore State.—According to Dr. Balfour, asbestos is found abundantly in both Salem and Mysore. It is probable that a large proportion of what is so called in the former district is chrysotile, which is known to occur with the serpentines (see page 333); if so, owing to the water of crystallisation which it contains, it would not be suitable for the purposes to which true asbestos is applicable. Information regarding the asbestos of Mysore is not available, but it may be worthy of attention.

Bengal: Chutia Nagpur.—In the metamorphic rocks of Chutia Nagpur, more particularly in those of the Manbhum district, true asbestos has often been found, but so far as is known at present, there are no abundant sources of it there.

Afghanistan.—According to Dr. Balfour, asbestos is found at Jellalabad. There is a sample in the Geological Museum, which was received recently from the Gabar Mangal country, together with the statement that it is used for making brooms. Mr. Wynne states that he has seen specimens from 2 miles west of Segai Kangah Khost, where it is so plentiful that the people make it into ropes; the locality is stated to be two long days' journey from Thal into Afghanistan.[1]

Punjab.—According to Mr. Baden-Powell,[2] a fibrous silky mineral believed to be asbestos, is found in the Bannu district, and a hard and stiffer mineral with finer fibre was obtained for the Lahore exhibition from another but unknown locality.

Garhwal.—Asbestos has been found, it is said, a short distance from Ukhimath in Garhwal. Mr. Atkinson[3] states that it is considered to be of good quality, but occurs too far inland to be worked with profit. It is used by the hill people as a dressing for wounds and burns, and as a wick for oil lamps.

Beryl Emerald: General Remarks.—This mineral is a compound of alumina, glucina, and silica. In the emerald the presence of less than one per cent. of chromium oxide confers the rich-green colour character-

[1] Records, G. S. I., Vol. XII, p. 111*n*.

[2] Punjab Products, p. 58.

[3] Economic Geology of Hill Tracts, North-West Provinces, Punjab, Allahabad, p. 34.

istic of the gem. By Mr. Lewy it was supposed that the colour was due to the presence of a carburet of hydrogen of organic origin. But the fact that emerald may be heated to a high temperature without losing its colour is considered to disprove this view.

As has been stated on page 429, the oriental emerald is a green sapphire or corundum. The other varieties of beryl are coloured by oxide of iron, and are of pale tints. The name aquamarine includes those of a sea-green or bluish-green colour.

As is well known, the emerald is a favourite stone with the natives of India; possibly, had it been produced in the country it might not have been so. With the solitary exception of Ajmir, in no part of India is it recorded that emeralds have been found; and the Ajmir emeralds were perhaps chryso-beryl. In all probability a proportion of the emeralds now in India have been imported overland from the north and west in small parcels, of which there are no trade returns. It is considered that Central Asia and Siberia have been the principal contributors; but in all probability Peru and the other known sources of emeralds have supplied their quota, and the imports from the London market are known to be considerable.

Madras: Coimbatore District: Paddoor or Patialey.—A beryl mine at the above locality has been described by Captain Newbold,[1] who visited it some years after mining had ceased. The rock is a vein or dyke of coarse granite, consisting of quartz, cleavlandite felspar, garnet, and several kinds of mica; the greater part of the mass is porphyritic, but in places it has a sort of fibrous structure. The beryl is found in nests in cavities in the cleavlandite. All the easily accessible masses of it had been broken up. The mine was worked for two years about the year 1818, by Mr. Heath, whose name has been mentioned in the Chapter on Iron. The villagers had previously been in the habit of collecting the beryl and selling it to itinerant jewellers, who again sold it at a high profit in Madras.

Aquamarine crystals from Kangiam in Coimbatore were exhibited at the Vienna exhibition. The aquamarine from Hindustan, to be seen in collections in Europe, was probably all obtained in Coimbatore. Some crystals of enormous size are said to have been sent from India.

Captain Newbold alludes to a report that beryl is also found at Vaniambadi, at the northern base of the Nilgiris, and there is a not very clear reference by Dr. Clark[2] to the occurrence of beryl in Mysore.

[1] Edin. Phil. Jour., Vol. XXXIX, page 171; and Madras Jour. of Lit. and Sci., Vol. XII, page 173.

[2] Madras Jour. of Lit. and Sci., Vol. IX, p. 121.

Bengal: Hazaribagh District: Mahabar Hill.—According to Mr. Mallet,[1] small crystals of yellow beryl are abundant in a large dyke which crosses the Tendwaha river, south of Mahabar hill.

Rajputana: Ajmir District.—According to Dr. Irvine, small rolled pieces of beryl of green colour, which the natives regarded as emerald, though they knew them to be softer than the oriental emerald, used to be found among the Sora hills near Rajmahal on the Banas.[2] There is apparently no more recent account of this mineral.

Panjab.—Beryl occasionally occurs in the veins of granite which traverse the gneiss at the Wangtu bridge, and for some miles up the Sutlej and Wangur rivers, also in the similar veins of the Chandra valley, above the Hainta pass. Mr. Mallet[3] who collected them in these localities, states that they are generally of a light-blue colour, but are too flawed to be fit for jewellery. The mineral is found in those parts of the granite where tourmaline also occurs. The largest crystal in the Geological Museum from this locality is 3½ inches long and ¾ inches in diameter.

Burma.—The Rev. Mr. Mason states that beryls have been found in the sands of the Irawadi, and he suggests that they might also be found in the streams descending from some of the granite hills. Authorities seem to be divided as to whether the true emerald has been found in Burma. The oriental emerald, however, occurs there, as has been already stated (page 429).

Garnet: General Remarks.—The varieties of garnets are legion; they form a genus, the species belonging to which vary widely in their chemical composition. They may be grouped in six sections, as alumina-lime garnets, alumina-magnesia garnets, alumina-iron garnets, alumina-manganese garnets, iron-lime garnets, and lime-chrome garnets, or in three sections simply, as alumina, iron, and chrome garnets, in which one of these is the sesquioxide base of the silicate, and the protoxide base is either lime, magnesia, iron, or manganese. To the alumina section belong the precious and common garnets, and also the cinnamon stone; to the iron section, colophonite, &c.; and to the chrome section green garnet or ouvarovite.

The carbuncle of the ancients is garnet cut, as it is called, *en cabuchon*. The art is still practised in India, and the stones, when of good quality

[1] Records, G. S. I., Vol. VII, page 43.
[2] Topography of Ajmir, p. 160.
[3] Mem., G. S. I., Vol. V, page 168.

and well cut, are very beautiful and would meet with more esteem were it not that they happen to be cheap, which has put them within the reach of so large a circle that they are made but little use of. It is believed, however, that there is still a small trade in them from Calcutta.

Madras.—Garnets occur in considerable abundance in most of the districts of Madras, garnetiferous varieties of gneiss being common. Green garnet was found by Newbold at Sankerrydrug in Salem, and the variety known as cinnamon stone or hessonite near the Seven Cairns hill on the Nilgiris. The dark-brown colophonite is widely distributed.[1]

Nellore District.—Garnet sand is collected in the rivers of Nellore and is sold by the natives as a substitute for emery. Mr. Foote[2] suggests that staurolite, of which an abundance is to be had near the Chundi hills, would be a more efficient substitute on account of its greater hardness.

Godavari District: KONDAPILLI, Lat. 16° 38′; Long. 80° 36′.—Kondapilli has long been famous for its garnets which are obtained from the detritus of certain bands of massive, garnetiferous, hornblendic gneiss. These garnets are now, however, of little value.[3]

Hyderabad State: GHARIBPETH.—At this locality, which is 8 miles to the south of Paloncha, precious garnets used to be collected according to Dr. Voysey.[4] They were found at a depth of 8 or 10 feet in the detritus, from which he was led to conclude they had been formed there, and had not come from the neighbouring granite rock in which garnets of inferior character only were to be seen. The garnets when collected were gently pounded; those which did not break were considered to have passed the test. Kyanite was very abundant in the granite. According to the Central Provinces Gazetteer, large quantities of garnets are still sent to Madras from Paloncha to be made up into ornaments.

Vizagapatam District.—Garnets are obtained in the hills near Galekonda. Indeed the metamorphic rocks all along the Eastern Coast are more commonly garnetiferous than are those in other parts of the peninsula.

Orissa.—The bed of the Mahanadi in Orissa contains garnets which used to be washed for formerly. Garnetiferous gneisses are very abundant in the province.

[1] Jour. Roy. As. Soc., Vol. VII, p. 224.
[2] Mem., G. S. I., Vol. XVII, p. 164.
[3] King, W. *Op. cit.*, Vol. XVI, p. 264.
[4] Jour. As. Soc. Bengal, Vol. II, p. 404.

Bengal: Chutia Nagpur: Hazaribagh District.—In several localities in Hazaribagh, including the station of Hazaribagh itself, massive garnet is found in veins in the metamorphic rocks. It is a somewhat puzzling-looking rock at first sight, and it has been mistaken for corundum, magnetite, &c. Ten years ago an attempt was made to push it in the market, but it apparently could not fetch remunerative prices.

In the year 1850, Mr. Piddington[1] analysed this massive garnet and conferred upon it the name calderite. From the numerous varieties which there are of it, it is more appropriately described as a rock than a mineral, as it does not possess a constant composition. The assay of the purest specimen gave—

Silica	46·35
Alumina	0·35
Lime	1·00
Arsenic	0·20
Iron perox	30·18
Manganese protox	21·00
Loss, partly fluorine	·92
	100·

Ordinary dodecahedral garnets occur in the schists in many parts of Chutia Nagpur, but there is no record of precious garnets having been collected there.

Central Provinces.—Garnets are obtained in the bed of the Godaveri near Bhadrachellum, but they are not of so good a quality as those from Gharibpeth.

Rajputana: Kishengarh State: SARWAR.—Lat. 26° 4′; Long. 75° 4′ 30″.—At this locality there are extensive mines in the Arvali schists from which garnets of large size and good colour are obtained.[2] In some cases the mass of garnet is amorphous in structure. According to the Ajmir Gazetteer, the Raja derives a large revenue from these mines; any one is allowed to work at the rate of one rupee per man, per day. For a distance of about a mile the outcrop has been burrowed into. It is believed that the large polished garnets cut *en cabuchon*, which are to be seen for sale in the principal towns of the Punjab, have been obtained in these mines.

Jaipur State: RAJMAHAL, Lat. 25° 53′ 30″; Long. 75° 21′ 30″.—At this locality there were workings, which were not quite so extensive as

[1] Jour. As. Soc. Bengal, Vol. XIX, p. 145; and XX, p. 207.
[2] Hacket, C. Records, G. S. I., Vol. XIII, p. 245.

the above, but they were conducted on the same principle and were in the same rocks.

Udepur State: MEJA, Lat. 25° 25′; Long. 74° 37′.—The mines here too were in all respects similar.

It would be useless to enumerate other localities in India where garnets exist; indeed materials do not exist for preparing a complete list.

Burma.—In Burma garnets of bright and clear colours are often sold to travellers by wily Shan jewellers as rubies.

Zircon: General Remarks.—This mineral is a silicate of Zirconia having the chemical formula $Z_r\ O_4\ Si$. Its square prismatic crystals belong to the dimetric system, but it is sometimes found in a granular condition. When the crystals are translucent and of a red colour they are called hyacinth. A colourless variety, with a smoky tinge, which is found in Ceylon, is called jargon; it is said to be often palmed off on the unwary as a diamond. This variety is used in the jewelling of watches. Zircon is occasionally obtained, it is believed, in the ruby mines of Upper-Burma, but as to its occurrence in India there is no information.

Iolite or Dichroite: GENERAL REMARKS.—This mineral is an aluminum, magnesium, and iron silicate. Its crystals are rhombic prisms of the trimetric system. It resembles sapphire or more closely blue quartz, but may, as it is softer than the former and is readily fusible on the edges, easily be distinguished from both. It is found in Ceylon, but it is not known to have ever been obtained in India, and the sole reason for its being mentioned here is that, recently, among some relics obtained at Buddha Gaya[1] and believed to have been ornaments of Asoka's throne, there were several samples of iolite, which may of course have been brought from Ceylon. It is noteworthy that these, which, if the antiquarians are right, must have been buried for about 2,000 years, show no sign of superfical alteration or decomposition.

Mica: General Remarks.—The group of minerals known collectively under the above name have several common characteristics, their principal points of divergence consisting in the combining ratios of the bases, and the silicon of which they are constituted. The light-coloured micas generally belong to the species known as muscovite and the black to biotite; other varieties are lepidolite and lepidomelane. Of all the species the only one having any real or extensive economic importance is muscovite, and to it therefore our present remarks may be confined.

[1] Procdgs. As. Soc. Bengal, 1881, p. 88.

Muscovite occurs in oblique rhombic prisms of the moclinic system. In composition it is somewhat variable, especially in reference to the water which it contains. Silica, alumina, potash, iron sesquioxide, and fluoric acid are its ordinary constituents.

The uses of mica all depend on its transparency, flexibility, thinness of its foliæ, and the ease with which it can be cut, while for special purposes its not being affected by great heat renders it invaluable. It is used in lieu of glass for lanterns, doors of furnaces, and in some countries in windows. As a glazing material for pictures and for the backing of mirrors, it is also employed. In India small fragments are largely employed in the tinsel ornamentation of temples, palaces, banners, &c. In powder it is used for ornamenting pottery, and even the clothes of the natives. By native artists it is much used for painting on.

Although mica is one of the most widely distributed minerals in India, its occurrence in plates of sufficient size to be of commercial value is limited to a few particular tracts. All the mica which occurs in rocks other than those of crystalline or metamorphic character is fragmentary or detrital, and of no substantial value, though it is collected to a small extent by the natives for ornamental purposes. The plates of useful size are found generally in veins of coarsely crystalline granite.

Madras: Vizagapatam District: KODUR.—Mica of sufficient size to be worth collecting is obtainable at the above locality, but as it sells at the rate of 24 pounds for the rupee it cannot be of a very good quality. It is said to be abundant.[1]

Bengal: Hazaribagh District.—The first mention of mica mines in this district appears to be by Surgeon P. Breton, who states that in the year 1826 large transparent laminæ were procured a few miles to the east of Hazaribagh station.[2]

In 1849 Dr. McClelland[3] described the mica mines at Dhanwi, Dhoba=Dhunbhar(?) and Quadrumma. At Dhanwi the mica is said to occur in strata alternating with coarse gneiss. The plates of mica are associated with large crystals of felspar and amorphous masses of quartz. About 50 to 100 men and boys were engaged in the mines, which were inclines running with the dip, and as many more women and children occupied themselves with sorting and dressing the plates. From this mine alone it is stated that 100,000 maunds were despatched to Calcutta, where they were sold at the rate of Rs. 7½ per maund. From the other mines still greater amounts were produced, and were sold on the spot for Rs. 4 a maund. These

[1] Vizagapatam District Manual, p. 155.

[2] Trans. of the Med. and Phys. Soc. of Calcutta, Vol. II, p. 261.

[3] Report on Geol. Surv., 1848-49, p. 20.

amounts seem incredible, as in other words the total annual value of the mica on the spot at the three mines would amount to upwards of £120,000, probably £1,200 was nearer the actual sum. In 1843 nine mica mines were at work on the Government estate of Kodarma, and the annual rent amounted to only Rs. 113-10-0.

In 1863, according to the Statistical Account of Bengal,[1] 10,000 maunds were exported at Rs. 3 a maund, or a total value of Rs. 30,000; half of this went to Calcutta and half to Patna.

DHUB, Lat. 24° 35'; Long. 85° 49'.—At the above locality and at Jamtara, in the Kharakdiha pargana, there are mica mines which have been described by Mr. Mallet, as follows. Having given the geological relations of the granite dykes, which he considers to be truly intrusive, he says that the "coarsest pegmatite is frequently found in dykes of moderate thickness, in which therefore plates of the largest mica occur, and it is such dykes that the miners generally select for their operations. They pay from one to two rupees each per annum, according to the richness of the yield, to the owner of the land for the privilege of mining. The usual mode of working is simply to excavate a trench along the course of the dyke, which in the Gawan neighbourhood is seldom carried deeper than 20 or 25 feet. Sometimes where there is a considerable thickness of decomposed mica near the surface, rude shafts are sunk to the fresh and uninjured mineral and excavations carried on laterally from the bottom. In a few cases also rough horizontal galleries are driven in from the side of a hill. In the last methods of course artificial light is necessary. No precautions are taken to support the roof and accidents are not unfrequent from its falling in.

"The plates of mica are generally brought to the miners' villages, and there, after being slightly trimmed with ordinary grass-cutting knives, they are sorted into different heaps according to quality and size. The quality depends on the mineral being in a perfectly unaltered condition, its transparency and freedom from cloudiness caused by internal foreign matter, the absence of minor cleavages which render it liable to split into ribbons and triangles, and the planeness of its fissile surfaces. Six kinds are recognised according to the size of the plates, *viz.*, *1st, sanjhla; 2nd, manjhla; 3rd, rasi; 4th, karra; 5th, urtha; 6th, admalla.* Some of the miners interpolate *failurtha* between the fifth and sixth, and speak of another size, *barka,* still larger than *admalla.* All these terms are used rather vaguely in respect to the absolute size of the plates indicated

[1] Vol. XIII, p. 171.
[2] Records, G. S. I., Vol. VII, p. 41.

thereby. At Dhub and Jamtara the miners were induced to separate a quantity of the mica into the different grades; measured average specimens of each gave the following results:—

	DHUB. Inches.	JAMTARA. Inches.
Sanjhla	5 × 4	4 × 3
Manjhla	7 × 5	5 × 4
Rasi	9 × 6	6 × 5
Karra	12 × 9	8 × 6

The above four sizes include the greater portion of the mica found, it being only in the best mines that *Urtha* and *Admalla* are procurable. The largest plates which were seen measured 19 × 14 inches, and 20 × 17 inches, but considerably larger ones are sometimes obtained.

"The mica is sold by the load, which is built up of plates either into one frustum of a cone and carried on the head, after being bound together with cord, or in two such and carried in a banghi. A load equals 6 *panseries*, one *panseri* being equal to 5 *kachcha* seers of 12 *chittacks* each, or 3¾ *pakka* seers of 16 *chittacks*; the load, therefore, being 22½ seers or 46 lbs. avoirdupois. The miners informed me that the prices paid to them per load by the mahajans were as follows: *sanjhla*, 3 annas; *manjhla*, 5 annas; *rasi*, 7 annas; *karra*, 12 annas; *urtha*, Rs. 2 to Rs. 5; *admalla*, Rs. 4 to Rs. 9, the selling prices being about double these figures. The value of the large plates more especially varies greatly with the quality. According to Colonel Boddam, plates of first quality of 18 inches diameter fetch as much as Rs. 60 a maund in the market, or about Rs. 30 a load.

Within the past few years some attempts have been made by a European to work some of these mines, but with extension of the operations the trouble and expense caused by water has increased so much that the work has, it is believed, been abandoned.

Behar: Gya District: RAJOWLI, Lat. 24° 40′; Long. 85° 35′.—In 1851, Captain Sherwill[1] described certain mica mines which are on the western prolongation of the zone in which the Hazaribagh mines occur.

During the three working months about 400 maunds of mica, yielding by calculation 23,000,000 transparent plates 9 inches square, were carried away from these mines to Patna. The value of the whole was estimated to be about Rs. 4,000. The miners belonged to a tribe called Bandathis, who were paid in kind about Rs. 2 a month by the mahajans. Before opening the mines, sacrifice to the tutelary goddess and general drunkenness were essential preliminaries. The pits were

[1] Jour. As Soc. Bengal, Vol. XX, p. 295.

seldom more than 40 feet deep, and were forsaken when they became too dark to work in. A test applied to the mica by the workmen was its capability of reflecting the face without distortion.

Central Provinces: Balaghat District.—In this district, at Chitadongri and Bamni, near Baihar, mica occurs in plates of 2 by 3 or 4 inches; these are too small to be of much value, but it is stated that the lease of the mines were taken by a French gentleman resident at Mundla, with what result is not known.[1]

Bombay: Rewa Kantha District: JAMBUGHORA.—Major J. Fulljames, in the year 1852, directed attention to the mica obtainable at the above locality; the plates were not of large size and were worth only from Re. 1 to Rs. 2 a maund at Baroda.[2]

Lapis Lazuli: General Remarks.—This mineral, otherwise known as ultramarine, has lost much of its value in modern times owing to the discovery by M. Guimet in 1828 of an efficient artificial substitute. Its composition is somewhat complex, as it contains silica, alumina, soda, lime, iron, sulphuric acid, sulphur and chlorine. The colour, which varies from a rich Berlin to an azure blue, is supposed to be due to sodium sulphide. The composition of the artificial substitute is identical, or nearly so, and acts similarly under chemical tests. Though generally found massive, its crystals, which are dodecahedrous of the isometric system, occasionally occur. The presence of scales of mica or crystals of pyrites often add to the beauty of this stone when polished. For ornamental purposes its uses are well known: when powdered it affords the beautiful pigment called ultramarine, which is worth £5 an ounce, and is preferred by artists in consequence of its possessing greater purity and clearness of tint than the artificial substitute. The latter is now commonly sold in the bazars of India under the same name, *lajward*, for about Rs. 4 a seer, while at Kandahar in the year 1841, according to Captain Hutton, the true *lajward*, which was used for house painting and book-illuminating, was sold, when purified, at from Rs. 80 to 100 a seer. Mr. Emanuel states that the value of the stone itself, when of good colour, varies, according to size, from 10 to 50 shillings per ounce. In Europe, the refuse in the manufacture is calcined and affords delicate gray pigments which are known as ultramarine ash.

Lajward is prescribed as a medicine internally by native physicians; it has been applied externally to ulcers. That it possesses any real therapeutic powers is doubtful.

[1] Central Provinces Gazetteer, p. 18.

[2] Selections from Records, Bombay Government, No. XXIII, p. 101.

Dr. Irvine[1] stated in 1841 that lapis lazuli is said to occur in the Nagpahar hills of Ajmir, in association with iron pyrites, but there does not appear to be any more recent record of its occurrence.

According to Captain Hutton,[2] the lapis lazuli sold in Kandahar was brought from Sadmoneir and Bijour, where it is said to occur in masses and nodules imbedded in other rocks. He obtained a small specimen from Major Lynch, which was said to have been brought from Hazara, and he heard that it occurred in Khelat. Several writers speak of its occurrence in Biluchistan, but possibly this may be due to some confusion in names. Beyond a question of doubt it does exist in Badakshan, the mines south of Firgamu, in the Kokcha valleys, having been described by Wood in the narrative of his journey to the Oxus.

Badakshan: Firgamu: MINES, Lat. 36° 10′; Long. 71°.—The position given is that of the mines, not of Firgamu, which lies some miles further down the valley.

The entrance to the mines is on the face of the mountain at an elevation of about 1,500 feet above the level of the stream. The rocks are veined, black and white limestones. The principal mine, as represented in elevation, pursues a somewhat serpentine direction. The shaft by which you descend to the gallery is about 10 feet square, and is not so perpendicular as to prevent your walking down. The gallery is 30 paces long with a gentle descent, but it terminates in a hole 20 feet in diameter and as many deep. The gallery is 12 feet in diameter, and as it is unsupported by pillars accidents sometimes occur. Fires are used to soften the rock and cause it to crack; on being hammered it comes off in flakes, and when the precious stone is disclosed a groove is picked round it, and together with a portion of the matrix it is prised out by means of crowbars. Three varieties are distinguished by the miners, the *nili* or indigo-coloured, the *asmani* or sky-blue and the *sabzi* or green. The labour was compulsory; and mining was only practised in the winter. According to Wood, these mines and also those for rubies had not been worked for four years as they had ceased to be profitable. Possibly this may have been partly due to the fall in value; according to Mr. Baden-Powell, recent returns represent the export as amounting to only 2 seers;[4] but Colonel Yule, in his book of Marco Polo, states that the produce was 30 to 60 poods (36 lbs each) annually, the best qualities selling at prices ranging from £12 to £24 per pood. Mr. Powell's figures perhaps

[1] Topography of Ajmir, p. 162.
[2] Calc. Jour. of Nat. Hist., Vol. VI, p. 604.
[3] London, J. Murray, p. 263.
[4] Punjab Products, p. 65.

only refer to the exports to India. Formerly the produce from these mines, which must have been considerable, was exported principally to Bokhara and China, whence a portion found its way to Europe.

Marco Polo says that the *azure* found here was the finest in the world, and that it occurred in a vein like silver. The Yamgan tract, in which the mines were situated, contained many other mines, and doubtless Tavernier referred to it when he spoke of the territory of a Raja beyond Kashmir and towards Thibet, where there were three mountains close to one another, one of which produced gold, another *granats* (garnets or rather balas rubies), and the third lapis lazuli.

A small quantity of *lajward* is said to be imported into the Punjab from Kashgar, and a mine is reported to exist near the source of the Koultouk, a river which falls into Lake Baikal.

Kyanite: General Remarks.—This is a subsilicate of alumina having the formula $Al_2 0_5 Si$. It occurs in gneiss, limestone and schistose rocks in thin-bladed light-blue crystals, in short and thicker crystals, or in a fibrous condition. Kyanite is sometimes used as a gem and has some resemblance to sapphire. Dr. Walker[1] in his account of Hyderabad, speaks of them as though they were different terms for the same mineral. The crystalline rocks of Hyderabad contain kyanite in some abundance. It is of tolerably common occurrence generally in India, and there are few accounts of large tracts occupied by metamorphic or crystalline rocks which do not refer to its presence, but in consideration of the fact that it is not a substance having any definite value, it will be unnecessary to go into further details here.

Topaz: General Remarks.—This mineral has nearly the same composition as kyanite, namely $Al_2 0_5 Si$, except that a part of the oxygen is replaced by fluorine. The crystals which are rhombic prisms belong to the trimetric system, and are differently modified at either extremity. Topaz is only found in metamorphic rocks, or in veins which traverse them. The colour of the topaz varies a good deal; the so-called Brazilian ruby is often a yellow topaz, which has been heated so as to bring out the red colour. The Brazilian sapphire is a topaz of a deep celestial blue. These varieties are in themselves valuable as gems. They may readily be distinguished from true rubies and sapphires by their inferior hardness; on the other hand they may be distinguished from several varieties of rock crystal, which they resemble by their superior hardness. The so-called oriental topaz of jewellers is really a yellow sapphire or corundum. Of the

[1] Madras Jour. of Lit. and Sci., Vol. XVI, p. 186.

occurrence of topaz in India there appears to be no authentic record, a reported discovery in the basalt of the Rajmahal hills being open to question.[1] Ceylon, it is believed, yields a not inconsiderable proportion of the topaz of commerce.

[1] Geological Report for 1848-49, p. 51.

CHAPTER XV.

BUILDING STONES.

General Remarks. IGNEOUS AND METAMORPHIC ROCKS—GRANITE AND GNEISS, &c.,—BASALT AND TRAP—DETRITAL ROCKS—SANDSTONES—LATERITE—SLATE—General Remarks—Madras—Mysore—Kadapah and Karnul—Bengal—Monghyr—Chutia Nagpur—Manbhum and Singhbhum—Central Provinces—Berar—Rajputana—Alwar—Bombay—Afghanistan—Punjab—Simla and Gurdaspur—Gurgaon—North-West Provinces—Kumaun—Darjiling.

Building Stones: General Remarks.—In this chapter there is a necessary departure from the order of arrangement of subjects, which has been adopted with reference to all the rest. There are two reasons for this change, one being the magnitude of the subject. If fully discussed there should be an amount of detail for which there is now no space in this volume; and it is perhaps needless to remark that there are several works in which the architectural part of the subject has been exhaustively treated of by specialists; on the other hand, both the calçareous and magnesian rocks, which afford the most beautiful and in some cases the most durable building stones, have already been disposed of in previous chapters. To reintroduce all the facts here, or to have dissociated the particular uses of these classes of rocks as building stones from the other uses to which they are put, seemed to be inconvenient and undesirable; this chapter therefore deals only with a part of the subject, namely, those building stones which are of crystalline (igneous and metamorphic), and those which are of sedimentary or detrital origin, limestones being excepted. Under these circumstances the geographical system of arrangement observed in other chapters has not been followed.

Throughout the Gangetic valley the public buildings which have been erected under the auspices of the British have, until quite recently, been built almost exclusively of bricks. In many cases the difficulty of obtaining a building stone within an easy distance of the towns situated in the alluvial valley, and in all the consideration of primary economy, have led to the employment of bricks instead of stone in the construction of our offices, courts, private residences, &c. Even in parts of the country where good building stones are to be obtained, bricks are often the only material regularly used. It is no doubt this feature of Anglo-Indian architecture, which in part gave rise to the saying that if the

English left India, in a century after their departure no sign of their occupation would remain.

Unfortunately the use of bricks cannot always be justified even by the appropriate or ornamental character of the results. If durability is sacrificed, we are justified in asking, if not for ornamental structures at least for buildings calculated to make this trying climate somewhat more endurable. But what do we find? To quote the words of Major (now Colonel) Medley: "Who does not know the scene of desolation that comes over one at first sight of some of our Indian cantonments: the straight and dusty roads, the rows of glaring-white rectangular barracks, the barn-like church differing only from a barrack in the presence of a square tower and classical! portico, the Roman Catholic Chapel ditto, only smaller and with bright-green doors all round"? And again: "It must, I think, be allowed that the true principles of architectural construction for buildings in the east, which are to be used by men habituated to an entirely different climate, have not as yet been discovered; a mosque, for instance, has a pleasant temperature both in winter and summer, while a Gothic church in India is, as a rule, either very hot or very cold. I do not say that Gothic churches are unsuitable to India, but only that they are so as we now build them."[1]

Of late years, however, and since the above was written, the improvement in design of public buildings in our larger towns is very marked.

Temples and houses built in the native style, though often somewhat close and ill-ventilated, are generally considerably cooler than any European buildings. This is particularly true of the massive stone structures of the North-west.

In new countries, such as Australia and America, the engineer or architect often experiences a difficulty in determining the durability of materials which he may wish to employ. Even in England this difficulty is not unknown, as is evidenced by the failure of the stone used in the construction of the Houses of Parliament; but in India, in the civilised parts, wherever building material occurs, ancient temples or other native buildings are almost sure to be found. These furnish all the information which can be required as to the durability of the stone when exposed to the atmosphere. The other qualities in building stones—strength, appearance, and susceptibility for ornamental treatment—can all be determined by simple and readily applied tests, but there is no known speedy test of durability. The presence or absence of certain minerals, or some peculiarity in the structure, are causes sufficient to determine the decomposition, which may be more or less protracted, but which must eventuate

[1] Professional Papers on Indian Engineering, Vol. I. pp. 201-2.

in the disintegration of the stone and the consequent disfigurement, if not total destruction, of the building in which it has been employed. With examples of stonework which range in age from before the Christian era up to modern times, the engineers and architects of India have thus an immense advantage over those of newer countries.

It should be scarcely necessary to observe that the proof of a certain formation, affording good building stone, is not sufficient to justify the conclusion that all the stone of that formation is equally durable. Yet the passing of individual blocks of stone is under these circumstances, there is reason to believe, often performed in an imperfect manner. Cases might be quoted where ill-chosen stones have not proved equal to the work which might justly be expected from the material had a little care been used in the selection, and thus, too often, a material has received a bad name and evil reputation where in truth its qualities have not been put to a fair trial.

Although locally, in the construction of bridges and other works, where stone has been employed, vast numbers of coolies have been trained so as to become very fair stone-cutters, still the number of highly *skilled* artizans is probably less than it was in former times, when the inhabitants of almost every district in India into which Aryans penetrated erected their temples of stone. In many cases these temples, to the present day, exhibit admirable workmanship in the most difficult materials.

To show how little has been done towards developing and rendering these resources of India available, it is only necessary to refer to advertisements which daily meet our eyes in the newspapers, of tombstones of Aberdeen granite and Italian marble. In further illustration of this, it may be mentioned that at Raniganj, 120 miles inland from Calcutta, there were to be seen, at the potteries, enormous granite mill-stones for crushing quartz which had travelled probably 15,000 miles to their destination, while within a radius of 20 miles several places could have been indicated where stone suited to the purpose could be obtained were quarries only opened up.

With increased facilities for carriage, by rail and canal, and with some modification of the traditions in favour of Public Works Department bricks, we may yet look forward to a time when the splendid building materials existing in India will be brought into more general use for our public and private buildings. And we may thus yet hope to see structures of an ornamental and lasting character worthy of our position in this country.

Granite and Gneiss.—Most of the so-called granite of India is a granitoid gneiss, a resultant of the excessive metamorphism of sediment-

ary rocks. To what extent true eruptive, igneous granite occurs in the peninsula is quite unknown. Granite, which, from its physical relations, one may venture to conclude is of truly igneous and eruptive character, is not, however, absent; but the physical relations accompanying exposures of perfectly unfoliated granites in the metamorphic areas of India are often not of a sufficiently definite character to enable one to assert with confidence the nature of their origin. There is no crucial test which can be applied to determine this question. Even microscopical examination of the minerals is not now considered to afford in all cases an infallible guide. These remarks seem a necessary preface to the following account, as travellers and antiquarians, who have described buildings, have often not attempted to characterise, more than by some very general term, such as granite or sandstone, the materials of which they have been constructed. Indeed by many writers the term granite is very incorrectly used, and it has sometimes been applied to the red sandstones of Northern India.

The metamorphic rocks occupy a very considerable area in India. East of a line drawn from Rotasgarh on the Sone through Amarkantak to Goa, the greater part of the country consists of them. The younger rocks which do occur in that area are for the most part limited to basins of comparatively inconsiderable size. Metamorphic rocks, not to mention small exposures within the limits of the great basaltic flows of Western India, also occur in Bundelkhand, Cutch, the Garo and Khasi Hills, and in the Himalayas. Whether these all belong to the same age or not is a question of some difficulty and uncertainty. The probability is that they do not, but lithologically there is sufficient general resemblance to justify their being all classed together in this account.

The varieties of metamorphic rocks suited to building purposes are of course very numerous. There are those caused by structure and those due to composition. By the former character they are divisible into foliated and non-foliated. The simplest form of the latter is a binary compound of quartz and felspar, or pegmatite, sometimes appearing as graphic granite. Then there are the ternary compounds, consisting of the two minerals just mentioned, with the addition of mica, hornblende, or talc, which are known respectively as granite, syenite, and protogine. Various modifications of these four varieties are produced by the presence of foreign minerals, such as oligoclase, schorl, garnet, epidote, magnetic iron, &c. As building stones the dense crystalline unfoliated varieties are the most durable. The presence of garnets or of magnetic iron is likely to be detrimental, as these minerals, under the influence of the atmosphere, are apt to disintegrate, and so mar the appearance, if they do

not ultimately endanger the stability, of the edifices in which stone containing them is employed.

In the alluvial tracts of Bengal ancient buildings of stone are of rare occurrence. Towards the west, however, in the rocky districts and on their borders, evidence is not wanting that the art of working in stone was practised whenever the material was available. In the Ganges, close to Colgong, there are several small hills which form islands in the present bed of the river. These hills consist of piled masses of a very compact gray granite, which in olden times used apparently to be resorted to for material for the construction of temples. The old holes for the wedges are still to be seen, and one enormous slab, which was partially split off, was never removed and still clings to its place.

In Behar many temples are to be found, in the construction of which granite was employed. Thus at Gya some of the Buddhistical rails and the floorings of temples, &c., are of this material. At Barabar hill occur the only recorded instances in Northern India of artificial caves excavated in these hard rocks. In sandstones and trap, as will be seen hereafter, not a few instances can be quoted. Throughout the Chutia Nagpur division, sandstones are generally more or less accessible, so that temples built of granite are of by no means common occurrence. But as we proceed southwards along the Eastern Coasts from Midnapur through Orissa, the use of granite seems to have been more common. At Niltigarh hill, in pargana Ultee, in Orissa, Hindu temples and deities are often made of garnetiferous gneiss, as are also some large figures in the Black Pagoda at Puri.

On Mahendragiri hill, in the district of Ganjam, there is a good example of what was not uncommonly the practice with regard to the construction of these temples. On the top of the hill is an unfinished temple, built of huge blocks of porphyritic gneiss, which on their exposed faces are rough and uncut. The practice appears to have been, not to have attempted any ornamental work until all the stones of the building were in position and then to have pared them, so to speak, into shape. One of the stones in this temple had the following dimensions, 9 feet × 3 feet 9 inches × 3 feet, which would indicate a weight of about 8 tons. The natives get over the difficulty of accounting for such megalithic structures by asserting them to be of supernatural origin, or by saying that "there were giants in those days."

In his report on the Nilgiri hills, Mr. H. Blanford[1] pointed out several places where excellent building stones could be obtained from the

[1] Mem., G. S. I., Vol. I, p. 244.

crystalline rocks; but not much use has been made of them hitherto. In Mysore a variety is obtained, which can be split into posts 20 feet long, and these have been used for the support of the electric telegraph wire. As readily accessible examples of the useful and ornamental purposes to which the gneisses of Southern India have been put, Mr. King[1] instances the following: A polished slab of quartzo-felspathic gneiss in the darbar hall in the Rajah's palace at Tanjore, which measures 18 feet × 16 feet × 2 feet 1½ inch; a small temple in the north-west corner of the Pagoda court at Tanjore, which is "a perfect gem of carved stone-work," the elaborate patterns on which are as sharp as when they left the sculptor's hands. Other beautiful examples of carving are to be seen at the Rock pagoda of Trichinopoli, at Volcandapuram, and at the Chellumbrum pagoda. "Even at Trivalur near Negapatam, at the eastern extremity of the great delta of the Cauvery, nearly 60 miles from the nearest gneiss quarries, the great pagoda and tank are surrounded by walls of massive gneiss."

"As an instance of the peculiar susceptibility of gneiss to fine carvings, the rings appended to the drooping corners of some pagoda buildings may be mentioned. These rings, the links within which are moveable, and the projecting corners, are carved out of single blocks of gneiss, such as may be seen at the Strimustrum pagoda."

Mr. King also mentions the use of blocks of gneiss in the construction of walls, *bands* of tanks, beach groynes at Tranquebar, culverts, bridges, &c.

At Mahavellipur or Mahaballipuram, in the Chingleput District, there are a wonderful series of temples which have been carved with an incredible amount of labour out of solid bosses of granite *in situ*.

The ancient Druid-like remains called Karumbar rings, which are found in various parts of Trichinopoli, generally consist of rough blocks of gneiss. In Chutia Nagpur old settlements of the Kols made use of gneiss in the erection of *menhirs* and *dolmens*. But, at the present day, the Kols who erect such memorials for the most part dwell in a part of the country where flags of schist and slate are readily accessible, and they therefore do not use gneiss.

In Madras Mr. Foote[2] according to the beds of very hornblendic gneiss which occur "at Palaveram, Cuddapary Choultry, and Puttandalum are largely quarried for the manufacture of articles of domestic use as well as for building purposes." Other varieties in different localities in

[1] Mem., G. S. I., Vol. IV, p. 367.
[2] *Op. cit.*, Vol. X, p. 131.

Madras are mentioned; some of these have been quarried to a considerable extent. One of the most singular uses to which the granitic gneiss of India is put is in the manufacture of agricultural cart wheels. Mr. Foote[1] has described this industry as it is practised in the Nellore-Kistna region. They are made of various sizes up to 6 feet in diameter, the prices varying from Rs. 8 to Rs. 20 per pair. They are said to become seasoned and stronger by age. At the village of Kuchupudi, about 100 pairs of wheels are cut every year.

Except for purely local purposes, the construction of bridges, &c., where, upon economical grounds, the rock nearest to hand has been made use of, the varieties of granite, gneiss, &c., on account of their hardness, have not commended themselves as building materials to English engineers. There are, throughout the country, no British buildings of importance, in the construction of which these materials have been used, except perhaps for rough work.

Bassalt or Trap.—Any one who has paid the smallest attention to the subject is aware that the greater part of Western India, the Deccan, and the Central Provinces is occupied by a vast accumulation of eruptive rocks, which are generally spoken of as Deccan trap. From north to south these rocks extend from a point 100 miles south of Gwalior to the vicinity of Goa, and from west to east from Bombay to Amerkantak, thus covering an area of about one-sixth of the peninsula south of the Ganges. Roughly estimated, we may put down the area in which these rocks prevail at 200,000 square miles. On the eastern side of the peninsula too, rocks, which, without going into details of the mineral constituents, may be conveniently spoken of generically as trap, occupy a by no means inconsiderable area, as in the Rajmahal hills.

From the evidence afforded by the sedimentary beds with which these rocks occur interbedded, those in the west appear to be referable to the close of the cretaceous epoch, while those of the east (Rajmahal) belong probably to the jurassic.

The whole of the trap rocks which are used for building purposes are not, however, exclusively derived from the two above-mentioned sources. In many other of the recognised formations in India the trappean rocks occur as dykes; sometimes these are basaltic, but in the older formations diorites prevail.

In the Deccan and Rajmahal areas, other rocks are not altogether absent, as there are not only the sedimentary, interstratified rocks above mentioned, but also, on the outskirts, the deeper valleys occasionally disclose rocks of older formations.

[1] Mem. G. S. I., Vol. XVI, p. 106.

The former, however, are not generally suited for building purposes, and are therefore less used than trap, which, though sometimes difficult to cut, is, if well chosen, a most durable material, and is moreover susceptible of much delicate and artistic treatment.

As might be anticipated in the Deccan area, from the enormous thickness of these rocks which occur, the lithological varieties are numerous. These varieties are due both to differences in mineral composition and degrees of compactness. With regard to the relative adaptability to building purposes of the various kinds of rock which are most commonly met with, Mr. Blanford[1] remarks: "None of the beds containing zeolites, interspersed in irregular strings and veins throughout the mass, are good. They are too soft, brittle, and liable to decompose. None of the ash beds are equal in strength, toughness, or resistance to the atmosphere to the solid basalts, and no rock of a red colour should ever be taken for building purposes. It is almost always decomposed. Amongst the very best beds are the porphyritic basalts, such as those which form so large a proportion of the rocks on the Thull Ghat." Mr. Bell[2] says: "The best I should consider to be the bluish-green basalt, which is very hard and heavy, having a specific gravity about 3·0, and which rings like a metal on being struck."

Probably the first use to which trap rock was put in India was in the manufacture of stone implements or celts, of which specimens are occasionally found, in some cases far removed from the places where the rocks occur. To a very early period must be referred that form of architecture which consisted in hollowing out and sculpturing the rock *in situ* into temples and dwelling-places, of which we have magnificent examples in the caves of Ajanta, Ellora, and Elephanta. These caves contain sculptures and inscriptions indicative of their Buddhistical or early Brahminical origin. Several of these caves are assigned to a period from 200 to 150 years B. C. At Gya, according to General Cunningham, some of the Buddhistical *rails* are made of basalt, others being of granite and sandstone.

Coming down to a more recent period, we find on the eastern side of India, trap from the Rajmahal hills made use of for lintels and door-posts in Hindu temples, and not unfrequently for the images contained inside. Trap used in this partial manner may be seen in many of the old buildings in the vicinity of Rajmahal and the ruined city of Gaur: occasionally, too, in temples in the Bardwan district. The 'black marble' of many writers is probably only this material. When covered by offerings of

[1] Mem., G. S. I., Vol. VI, p. 379.

[2] Professional Papers on Indian Engineering, Vol. I, 2nd Series, p. 162.

ghi, it is often, without doing what in the sight of the people would be regarded as desecration, impossible to make out the material of which the images are made. In the famous Black Pagoda at Puri trap is said to have been much used; this material was probably derived from dykes in the metamorphic rocks. In the Deccan and surrounding trap country this material has been used in the construction of forts and native buildings of various kinds. One of the most magnificent works in trap is stated by Dr. Balfour to be an unfinished tomb of one of the Gwalior Princes at Puna.

It has been extensively used in the construction of bridges and stations on the lines of railroad which traverse the trap country, but from causes for which the stone is not altogether in fault, but rather the lime and workmanship, the work has not always given complete satisfaction.

In the city of Bombay trap has been used to some extent, but chiefly in rubble masonry. All the finer buildings in Bombay are constructed of a very different material, as has been mentioned on page 465. The principal use to which the trap rocks of the Rajmahal hills are at present put, is for the supply of Calcutta with road metal.[1]

Sandstones.—Several of the recognised formations in India, namely the Vindhyan, Gondwana, Cretaceous, and Tertiary, afford sandstones admirably suited for building, and some of them have from very early times been largely drawn upon for the supply of materials for this purpose.

Vindhyan Sandstones.—Among all the above formations the great Vindhyan series stands pre-eminent. The difficulty in writing of the uses to which these rocks have been put is not in finding examples, but in selecting from the numerous ancient and modern buildings which crowd the cities of the North-Western Provinces and the Gangetic valley generally, and in which the stone-cutter's art often appears in its highest perfection.

The Lower Vindhyans,[2] consisting for the most part of shales and more or less flaggy limestones, and from the inaccessible position of the rocks in some of the principal places where they occur, as in the Son valley and Bundelkhand, have not been worked to any great extent.

The Kaimurs, however, have been worked extensively at Chunar, Mirzapur, and Partabpur, as well as at minor intermediate points. The

[1] Building materials, Bombay Island, Carter's Geology of Western India, Bombay, 1857, p. 161. Building stone in Western India, Merewether. Prof. Papers of Ind. Eng., Roorkee, Vol. VI, 1859, p. 130. Geology of Bombay Island, Wynne, Mem., G. S. I., Vol. V, 1864, p. 173.

[2] Mallet, F. R. Mem., G. S. I., Vol. VII, p.

sandstones are in general fine-grained and of reddish-yellow or greyish-white colours. They occur in beds which are said to vary in thickness—at Partabpur, and similarly elsewhere, from 6 inches to 8 feet. These beds often spread for long distances without any joints or fissures to break the continuity, in consequence of which very large blocks can and have been extracted for various purposes. In the Rewah group, overlying the Kaimurs, the sandstones are not so much used for building purposes. "This is due partly to the beds being frequently coarse and harsh, and greatly subject to false bedding; partly to the fact that the Rewahs do not as a rule occur close to the Gangetic valley or to large cities. Some portions are, however, of superior quality, and supply all local wants." Above the Rewahs come the Lower Bhanrer, which are described as being, for the most part, coarse, harsh, and gritty, and occurring only in thin beds.

The Upper Bhaurers, however, make up for the deficiencies of the underlying group by affording two varieties of excellent building stone, one dark red, sometimes quite unspotted, sometimes streaked and dashed with yellowish-white spots. The other is a yellowish white, very fine-grained rock, perfectly homogeneous both in texture and colour. The latter is said to be, on the whole, the better building stone on account of its more uniform colouring, and its being not so liable to disintegration from the effects of long-continued exposure.

Probably the earliest use to which any of the rocks of the Vindhyan formation were put, was in the manufacture of stone implements, many of which, formed of the denser indurated varieties of sandstone, have been found in India. There are no cave temples, or at least none of much note in the Vindhyan sandstones. But there are memorials of a very different class, many of which date from a period before which the idea of using stone in the construction of houses had not been entertained. At any rate, there are no buildings or remains of buildings which can with safety be regarded as belonging to so remote a period. These memorials are the great monoliths or *láts*, many of which bear the edicts of Asoka, the protector of the earliest Buddhists, who reigned about 250 B. C. Besides these pillars he is said to have erected 84,000 Buddhist sanctuaries called stupas or topes.[1] Some of these monoliths are of great size, and are generally polished throughout the portion intended to be exposed. They were surmounted by carved and ornamented capitals, upon which figures of lions or elephants were placed. The polished portion of the shaft tapered uniformly from base to summit, and in every way these remarkable monuments testify to considerable kill in the stone-cutter's

[1] Balfour's Cyclopædia, Art.—Asoka.

art. Still it would appear that this art was not made use of in the erection of buildings, and when the first stone temples[1] were excavated and adorned a century later, the stone architecture, as pointed out and described by Mr. Fergusson, was a "mere transcript of wooden forms," showing that at that time the art of using stone for these purposes was only being then first adopted, and that, though the material was changed, the workmen continued to use the designs suited to wood. It was only gradually through several succeeding centuries that the forms and designs became suitable to the material. It is considered by the best authorities that the palaces, temples, and buildings generally, of those early times were mainly constructed of wood, as they are for the most part in Burma and Siam at the present day.

As these *láts* afford the most striking evidence which can be given of the size of the stones which are obtainable from the Vindhyan sandstones, and the durability of the material, the following enumeration of the principal of them is appended. The details are chiefly from General Cunningham's Archæological Reports.

[1] Stone Monuments, Fergusson, 1872, p. 456.

Name.	Position.	Material.	Length. Observed.	Length. Estimated Total.	Diameter. Upper.	Diameter. Lower.	Weight (estimated).	Age or period.
Bakra or Bhim-Sen-ka lat	Beshrah, 27 miles east of Patna	Polished sandstone	32′	36′-37′	38″·7	49″·8	50 tons	Unknown.
Navandgarh	Lauria, 15 miles north of Bettia	,,	32′ 9½″	...	26″·2	35″·5	18 tons (polished portion).	Asoka (About 250 to 200 B. C.)
Ara Raj	Lauria, 15 miles north of Bettia	,,	36′ 6″	...	37″·6	41″·8	34-40 tons	,,
Firuz Shah's Pillar[1]	Delhi	,,	...	42′ 7″	25″·3	38″·8	27 tons	,,
,, No. 2[2]	Delhi	......	32′ 8″	...	29″·5	35″·82	...	,,
Bhim Sen-ka gada	Kosam, on the Jumna	......	28′	36′-40′	29″·5	...	...	? ,,
Allahabad	. . . .	......	...	42′	...	...	...	,,
Kahaon	46 miles south-east of Gorukpur	Coarse grey sandstone	24′ 3″	27′	...	...	...	84 A.D., or 219 A.D.
Bhutari	Between Benares and Ghazipur	Reddish sandstone	15′ 5″	...	28″·85	...	...	? 100 A. D.

[1] Removed by Firuz Shah from its original site in district of Salora near Khizrabad, on the Jamna.
[2] Said to have been brought from Meerut.

Mr. Mallet mentions two large blocks which are found "about a mile south-east of Rupas near the quarry from which they were cut:" the dimensions of these suggest a near connection with those enumerated above. Not improbably they belong to the Asoka period. One is a circular column 34′ 6″ long, with upper and lower diameters of 2′ 8″ and 3′ 3″. The other is a parallelopiped 42′ 6″ long by 5′ 3″ × 3′ 8″ and 5′ 9″ × 4′ 1″, with an estimated weight of nearly 60 tons. The neighbouring villagers appear to know nothing of their history.

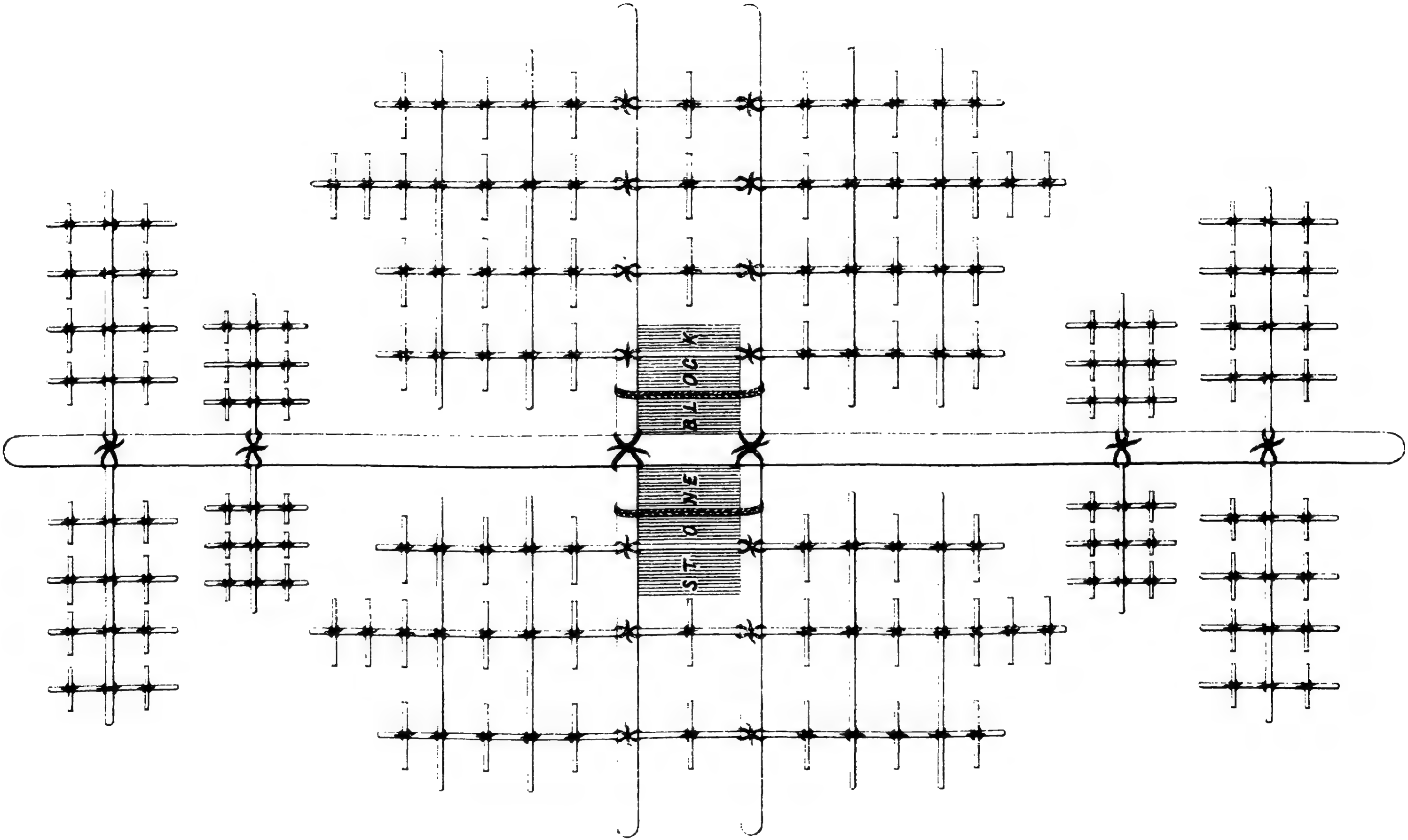
Plate VIII is a representation of a form of frame which is used in Northern India[1] for the purpose of lifting large blocks of stone. The first step in the construction of one of these frames is to lash two strong beams of timber on either side of the stone; these are crossed by other beams and so on till they come down to the bamboo cross-bars, each of which accommodates two coolies. Thus on their shoulders a large number of men are enabled to bear each a fraction of the weight of a very large mass of stone. In general terms, it is said that the weight of the frame is about equal to that of the mass to be lifted. That by some such arrangement the megalithic buildings of early times were supplied with stone seems very probable. Another method known to the natives for moving large masses of stone was to piece together very solid wooden wheels round the prismatic masses of stone which thus acted as axles. By means of strong cables worked by very crude forms of windlass these were made to roll in the required direction; for a reproduction of a native drawing of this process reference should be made to the paper quoted below.[2]

The quarries at Dehri on the Son are the most eastern of all those which have been opened in the Vindhyan rocks. At present they are largely worked in connection with the Son irrigation and canal projects. The stone is a compact whitish sandstone susceptible of artistic treatment, and, what is of more importance for the present purpose to which it is put, strong and durable. The next point of importance where there are quarries is Chunar. The Ganges river has, during a period of at least 2,000 years, been availed of as affording a ready means of transport for the excellent building stones which are obtained from the Kaimur rocks at Chunar. The East Indian Railway now affords an additional means of transport, but is, however, not very much used for the purpose, water carriage being so very much cheaper.

Benares, and other cities and towns of less note, both in ancient and modern times, have largely used Chunar sandstone. The ghâts at Benares, the palaces, the walls, the minarets, and many of the temples are built of this material. To Calcutta a certain quantity is brought for paving and tombstones, &c. The only stone church in Calcutta is St. John's, which is built of Chunar stone. It has also been used to some extent in other buildings in Calcutta, but for paving purposes, as has elsewhere been shown, the so-called Bardwan stone has also been employed.

[1] Selections from Records, North-West Provinces Government, New Series, Vol. V, p. 316.

[2] Professional Papers on Indian Engineering, 2nd Series, 1878, Vol. III, p. 1.



Frame used for moving large masses of Stone in Upper India

The next quarries to be mentioned are those of Mirzapur, which, with those of Partabpur and Seorajpur, have supplied Mirzapur and Allahabad with material for the construction of their buildings, both ancient and modern.[1] The stone for the Jamna bridge was, according to Mr. Mallet,[2] obtained from some quarries a few miles up the river, whence it was brought down in boats.

From this the limits of the Vindhyan rocks sweep southwards forming a great bay, and the next place where they have been worked to any large extent is in the neighbourhood of Gwalior, where they have been used in the construction of forts, temples, &c. It may be mentioned, too, that on the exposed cliffs of sandstone there are some carved figures of Titanic dimensions.

Although, as was remarked, the sandstones of the Rewah group are not generally used, still "in the neighbourhood of Hoshangabad, and also in Sipri and Gwalior some thin red flags from ⅛ to 1 inch thick are much used for roofing."

Perhaps the most important quarries in India are those in the Upper Bhanrers to the south of Bhartpur, at Fatipur Sikri, and Rupas, which have furnished building materials since before the commencement of the Christian era to the cities of the adjoining plains. Portions of the Taj at Agra, Akbar's palace at Fatipur Sikri, the Jamma Masjid at Delhi, and buildings generally in Agra, Delhi, and Mutra (Mathura), have drawn upon these quarries for their materials.

To quote Mr. Mallet again: "The palace of the Rajah of Bhartpur at Deeg, which is regarded as one of the most beautiful edifices in India, testifies at once to the excellence of the stone employed and the skill attained by the stone-cutters of that district. Cupolas resting on slender shafts of 2 and 3 inches diameter, arches supported on strong, yet graceful pillars, windows formed of single slabs of stone perforated with the most elaborate tracing, meet one at every turn."

In conclusion, it may be mentioned that the sandstones both here and at Chunar were largely used for telegraph posts; the facility with which some of the varieties split rendered it possible to obtain posts 16 feet long of material which would resist white-ants and the action of the weather. These have of late years, however, been replaced by pillars of galvanized iron, as they were found to be liable to snap in two during strong hurricanes.

Thus the ancient pillars of Vindhyan sandstone have been instrumental in annihilating time by preserving in an imperishable record

[1] Owen. Professional Papers on Indian Engineering, Rurki, Vol. II, 1865, p. 81.

[2] Mem., G. S. I., Vol. VII, p. 116.

fragments of the history of upwards of two thousand years, while the posts of to-day have been subservient to the destruction of space, for it may be said that the telegraph which bears our messages from Calcutta to Peshawur, over a distance of 1,500 miles, in a few seconds of time, practically overcomes space.

The preceding remarks refer only to the Vindhyan rocks, as exhibited in the Great Vindhyan and associated ranges on the south of the Gangetic valley. In order to complete this notice, it will be necessary to allude to the occurrence of rocks believed to belong to the same geological period in other parts of the peninsula.

Between Sambalpur and Raipur, in the valley of the Mahanadi, a series of sandstones, shales, and limestones, considered to be contemporaneous with the Lower Vindhyan series, occupy a considerable area. But in that part of the country there has as yet been only a limited demand for building stones. Gradually, however, the use of stone in the town of Raipur is increasing. Again, rocks referable to the Vindhyan series occur in the country to the south of Nagpur, in the region about the confluence of the Wainganga and Wardah rivers.

In the Karnul district south of the Kistna, there is another series of limestones, shales, and quartzites which is considered also to be referable to the lower Vindhyans. Mr. King, in his description of these rocks and the underlying Kadapah formation, says: "There is no lack of good and easily-wrought varieties of stone all over the district; but these can only become of value as they are locally required, or as the means of communication are opened out over the district."[1]

For further examples of the uses to which the Vindhyan sandstones have been put in ancient times, reference should be made to General Cunningham's Archæological Survey Reports.

Gondwana Sandstones.—Among the sandstones of the Damuda series there are several varieties which are suited for building purposes, and which have already to a small extent been made use of. Throughout the Damuda valley, where these rocks occur, they have been used in the construction of temples, some of which are of considerable antiquity. Among the finest examples three Jain temples at Barakar are deserving of particular notice, as exhibiting some rather elaborate carving which has stood well. But still more ancient work in this material is to be seen in the caves of Sirguja and Chang Bakhar, which bear inscriptions in the old *Pâli* character, testifying to their extreme antiquity. In recent times the sandstones at Barakar have been quarried largely for local use in the

[1] King. Kadapa and Karnul Formations. Mem., G. S. I., Vol. VIII, p. 281.

construction of the Barakar bridge, and for various purposes in connection with the East Indian Railway. A considerable portion of the new High Court in Calcutta is also built of this material. Being readily accessible at the terminus of the Barakar branch of the railway, this rock will probably always be more or less used for purposes to which brick is not suited.

In Hazaribagh and Ranchi some of the sandstones of the Damuda series have been used to a small extent, and the flaggy beds of the underlying Talchirs to a somewhat larger extent, for paving the European barracks, &c. References to these sandstones will be found in the numerous reports on coal-fields in the Memoirs and Records of the Geological Survey.

The sandstones of the various groups included in the Upper Gondwana series have been largely used; the members of the older groups are, however, in many cases either too friable, or contain too much iron to be lasting when exposed to the atmosphere. In the Bagra group, there are sandstones applicable to building purposes, and which have been used to some extent locally; thus the Tawa viaduct is built of these sandstones.

Some of the beds of sandstone in the Jabalpur group yield a useful building material. A very dense indurated variety, which occurs in the station of Jabalpur, has been quarried to a considerable extent for local purposes.[1] The viaduct over the Narbada below Jabalpur furnishes the most important example of the applicability of the sandstones of this group to building purposes.

Close to Cuttack there are sandstones belonging to the Rajmahal group. These were used in the construction of temples at Bobaneshwar, and to some extent for various building purposes in Cuttack; but laterite and gneiss seem to have been more largely employed. The famous ancient caves at Kundagiri have been excavated in these rocks.[2]

The intertrappean rocks of the Rajmahal series, whose contained fossil plants present a markedly jurassic facies, consist of sandstone, flag beds, and shales. The two former are occasionally employed for local building purposes, but cannot be considered to be of much importance.

The compact sandstones of this series at Conjeveram and several other places offer, according to Mr. Foote, a very easily dressed and moderately durable building stone.[3]

[1] Medicott. Records, G. S. I., Vol. V, p. 77.

[2] Building materials of the District of Cuttack. Jour. As. Soc. Bengal, Vol. XI, p. 836. Mem., G. S. I., pp. 250 and 277. Records, G. S. I., Vol. V, p. 59.

[3] Foote, R. B., on the Geology of Madras. Mem., G. S. I., Vol. X, p. 132.

In reference to the jurassic rocks of Cutch, Mr. Wynne says: "The finer-grained slightly calcareous yellow sandstones of the lower jurassic group form tolerable building stone; and some of the close, hard, silicious grit bands, though difficult to trim or dress fine, would afford a very lasting material for rough work." Several other sandstones are locally used. Mr. Wynne gives a list of the different building stones used in Bhuj, as furnished to him by His Highness the Rao of Cutch.[1]

Cretaceous Sandstones.—The Bagh beds, which belong to the cretaceous period, contain some good sandstones suited to building purposes. Mr. Blanford, in his report on Western India, says: "The massive sandstone of the Deva, and those which occur throughout the country to the south of Allirajpur and Bagh, would furnish excellent material. The gritty calcareous bed at the top, where it is not too cherty, would be well adapted for construction and could be easily worked.[2]

Tertiary Sandstones.—The rocks of the Siwalik and Nahan groups which represent the upper and middle tertiary period of Europe, are generally too unconsolidated to form durable building stones. These rocks, as is well known, form the outer ranges of the Himalayas at various places from west to east; but among the eocene beds better materials are found. Mr. Medlicott remarks: "Those stations, as Dagshai, Kasaoli, Subathu, Dhurmsala, which are built on the eocene groups of the sub-Himalayan series, have an unfailing supply of good building material in the massive sandstone rocks. Among the older rocks there is no stone fit for anything but that for which rough rubble may be used. There are several examples of native architecture along the border of the plains, for which an excellent building stone was obtained from rocks of the Sivalik group, but it must have been found in detached blocks and discontinuous bands, the mass of the rock being quite unfit for the purpose. Stone fit for ornamental or monumental purposes might be found among the thick-bedded, hard limestones of the Krol group." [3]

Quartzites.—The gradation from the loosest and most granular sandstone to the most intensely vitrified quartzite is so complete that it is impossible to draw a sharp line of demarcation between them; they are therefore placed in close proximity in this enumeration. Were the arrangement a purely geological one, a large portion of them would have to be classed with the metamorphic schistose or gneissic rocks.

If we except those varieties of the Vindhyan and Karnul sandstones

[1] Wynne, A. B. Geology of Cutch. Mem., G. S. I., Vol. IX, p. 93.
[2] Blanford, W. T. Western India. *Op. cit.*, Vol. VI, p. 380.
[3] *Op. cit.*, Vol. III, p. 175.

which are sometimes called quartzites, the use of rocks coming under this denomination has been inconsiderable. In Bengal the only instance known of a quartzite being regularly quarried is in the Susunia Hill in Manbhum. The works there were carried on for some years by the Bardwan Paving Stone Company, and large quantities of the stone have been used in Calcutta for pavings, copings, and other similar purposes. There are several varieties of this material found; in some there is a large proportion of felspar, which should therefore be called granulit rather than quartzite.

Although these rocks have been so little used, the Bijawar or sub-metamorphic series, in many parts of the country, afford quartzites suitable for building purposes; wherever these occur in the vicinity of Vindhyan sandstones, the latter will naturally be preferred, as they are in most instances much more easily worked. The vitreous fracture of many quartzites is in fact a bar to their employment where much finish is required. Mr. Foote[1] gives a, so far as is known, unique instance of the employment of this material in the manufacture of a highly finished monolith at Bilzi, 12 miles north-east of Kaladgi. The pillar is about 35 feet high. It is cut alternately in squares and octagons, the sides of the former at the base measuring 1 foot 6 inches.

Laterite.—The term laterite has been applied generically to a group of tertiary rocks which occupy an important position in the superficial geology of India. The common character which persists throughout all the varieties of laterite is the possession of a ferruginous element, which is in the form of brown hydrated peroxide on the surface, sometimes as the black magnetic ore inside. The reddish-brown appearance, due to the presence of the peroxide, explains the origin of the name (*lateritis*, a brick), which was first conferred upon it by Dr. Buchanan.[2]

The various forms in which laterite occurs are due to differences of composition and differences of structure. The combinations of these two qualities produce almost infinite varieties. The principal structural varieties are either nodular or cellular, the former being generally the younger, and it is supposed, in a measure, derived from the latter. The varieties in composition vary much in the quantity of the peroxide of iron which they contain, and in the character of the other materials. Both classes pass off into mere detrital laterite, to the ferruginous element in which they have no doubt mainly contributed.

The distribution of laterite is widespread throughout the Peninsula,

[1] Mem., G. S. I., Vol. XII, p. 761.

[2] Journey through Mysore, Vol. II, p. 441.

India, Ceylon, and in Burma. It occurs not only as a coastal deposit underneath the Eastern and Western Ghâts, but also in many parts of the interior, not unfrequently capping lofty hills and plateaus with a thickness of several hundred feet, often producing the dead-level surfaces which constitute a striking feature in Indian scenery. Although perhaps it shows its finest development on or in the vicinity of trappean rocks, it occurs resting on rocks of all periods, occasionally far removed from any exposure of trap.

As a building stone, though it can hardly be called ornamental, it possesses some qualities which render it acceptable in the eyes of the natives; it is easily worked, hardens on exposure, and some varieties of it wear well. In the coastal districts many temples, some of considerable antiquity, are built of laterite and appear to have stood well. In the Rajmahal hills there is a small fort built of neatly-cut blocks of laterite without mortar. These blocks have retained their original sharp edges. In Midnapur and Orissa slabs of from 4 to 5 feet long are extracted by cutting a groove round the slab above and another underneath, a few wedges are then driven into the latter, and the slab splits off. This or a nearly similar process is used for the extraction of blocks of laterite in all parts of the country where it is worked by natives.[1] Laterite has been largely used in the works in connection with the irrigation operations in Orissa. The anicut on the Kossai at Midnapur has been altogether built of this material. The stone for these purposes is reported to have given the engineers much satisfaction.

Mr. King,[2] in his Geology of Trichinopoli, says: "Where of poor quality, the laterite soon crumbles away when exposed to the influences of weather and moisture, as may be seen in the basement of many of the houses in the fort of Tanjore. The laterite has there weathered away, leaving the walls perfectly honeycombed, and the layers of mortar, which are more durable, standing out as a regular net-work." In a note Mr. Foote adds: "The laterite in this case was in all probability badly selected, for in all my subsequent observations of this stone as a building material, it would appear that continued exposure to atmospheric influences, or wet, as in the case of tanks or bowries, only tends to improve the stone. Most of the religious edifices and tanks constructed of this stone show the lines and angles of the carvings as sharply as though fresh from the builder's hands."

Mr. H. Blandford[3] also remarks: "At Andanapet I noticed some

[1] Mem., G. S. I., Vol. I, p. 277.
[2] *Op. cit.*, Vol. IV, p. 372.
[3] *Op. cit.*, p. 206.

carved blocks forming part of an old ruined pagoda, the mouldings of which were as perfect as when first cut. Owing to its porous structure, however, laterite is but little fitted for fine sculpture."

The Vellour anicut at Chetia-tope, near Bhowagiri, in the Trichinopoli district, is partly built of laterite. Dr. Balfour gives the Arcade Inquisition at Goa, St. Mary's Church, Madras, and the old fortress at Malacca, as examples of its use in the construction of buildings by Europeans.[1]

Slate.—True slate, as the term is usually accepted, is a homogeneous rock, which, owing to the presence of the superinduced structure, termed cleavage, is almost indefinitely fissile. By far the majority of the so-called slates of India do not possess this property; they are fissile, but the planes correspond to those of lamination, *i. e.* of original deposition, and the splitting cannot be carried to such an extent as to produce very thin, or in most cases even tolerably thin slates. The consequence is that for sloping roofs they are not generally well adapted, being heavy and requiring proportionately strong timbering. Even where locally an exceptional degree of fineness of texture and capability of sub-division is present, this cannot be counted on to extend through a large mass in the same way that the effects of cleavage are discernible through a great thickness and wide extent of rock.

Thick laminated slates, which are not suitable for sloping roofs, may of course be employed for flat roofs and for paving instead of tiles. In this way, owing to their strength, they may be used of much larger size than would be safe to give to tiles, and stretching from beam to beam they may actually cause a great economy in timbering, and the concrete which is laid upon tiles might, where slate was used, be very considerably diminished. Another advantage of the use of large flag-like slates would be that as the number of joints are diminished the chances of leakage are likewise lessened and so also the consequent cost for repairs.

Madras : Mysore State.—A slate suitable for drawing purposes is found in the neighbourhood of Chitaldrug, and a chlorite slate is also said to occur in Mysore, but whether it is applied to roofing purposes is not stated.[2]

Kadapah and Karnul Districts.—In these districts slates occur, to which a good deal of attention was directed about twenty years ago. The splitting with the planes of lamination only produces tolerably thin slates, which are not suitable for roofing, but would answer for flagging

[1] Balfour, Cyclopædia, *Art.*—Laterite.

[2] Mysore Administration Report (1868-69), Statistics, p. 4.

and similar purposes; but in order to obtain neat slabs much improvement in the quarries and methods of splitting would be required.[1]

Bengal: Kharakpur Hills.—In the transition rocks of the Kharakpur hills there is a band of slates, from 6 to 12 feet thick, which is traceable for many miles on the northern margin of the hills between Rishi-kund on the east and the Gouria and Amrasanni kols on the west. Being for the most part vertical, it can only be worked by steps on the sides of the hills, or by actual mines. A cheap system of open quarrying seems to be wholly inapplicable to the circumstances of the deposit. For many centuries this slate has been worked by the natives more after the fashion ordinarily practised with reference to veins of metallic ore than to deposits of slate; the petty mines and quarries serve to produce an amount of slate which is equal to the demand, but the cost is certainly high.

The slate is a partially altered earthy rock, which is readily fissile with the plains of lamination; with pains and care it can be reduced to a thickness of one-eighth of an inch; but its surface is scaly and rough, and it would require much grinding and polishing to make it suitable for drawing upon; ordinarily at the quarries the slates are from ¼ to ½ an inch thick. For flagging it would probably answer fairly well, but its chief employment is for roofing instead of tiles, and a large quantity is so used at Monghyr and the neighbouring towns; curry platters, &c., are also made from this stone to some extent.

The following are the rates paid to the bildars or quarrymen by the present contractors:—

Slates	12″ × 4″	6 annas per 100.
	12″ × 6″	8 „ „
	12″ × 12″	12 „ „
	18″ × 9″	14 „ „
	18″ × 18″	18 „ „
Round platters in diameter	1′ × 3″	10 annas for six.

A ghâtage of 2 annas per 100 is charged by the zemindar.

Much improvement might be made in the rude and wasteful system of mining, but whether it would pay to do so must depend upon the demand, which as yet has shown no tendency to expand, as tiles are very much cheaper.

Chutia Nagpur, Manbhum and Singhbhum.—In these districts flaggy laminated slates occur in many places in the sub-metamor-

[1] Mem., G. S. I., Vol. VIII, p. 283.

phic rocks; but as yet they have not been worked as there is no local demand. With a little polishing, slates suitable for drawing upon can be made from the rough material obtainable near Chaibassa and some of the varieties are fine grained and equal to, if not better than, the Kharakpur slates. In some cases a regular cleavage structure was found, but it was not apparently accompanied by obliteration of the lamination, and the slates therefore break up into slips with a rhomboidal section.[1]

Central Provinces.—Slates with imperfect cleavage occur both in the Chanda and Chindwara districts, but as yet they do not appear to have come into use.[2]

Berar.—In the pargana of Patan Biri in the Wun taluk, slate is said to occur, but the extent of its applicability to useful purposes is not known.[3]

Rajputana: Alwar State.—According to the Alwar Gazetteer[4] slates are found at Bilaspur in Ramgarh; but at Mandan in the north-west corner of the State, the chief source of supply is situated. There are, however, but few families of workmen, as the slates are only in demand for European buildings, such as railway works, churches, and schools. These slates doubtless belong to the Arvali series of transition rocks.

Bombay.—There are several early papers in which there are descriptions of varieties of slates found in the South Mahratta country, and in the most recent account of this region by Mr. Foote,[5] in which many varieties of building stones are alluded to, mention is made of slates belonging to the Kaladgi series, as having been worked formerly for roofing public buildings at Belgaum.

In the Champanir rocks between Surajpur and Jambughora, north-east of Baroda, there are some slates which, as far as can be judged from their appearance at the surface, were considered promising by Mr. W. T. Blanford.[6]

In the Bijawar series near Bagh there are also some slates which are not so fine grained as the preceding, but some of which might perhaps answer for roofing purposes.

Afghanistan.—Dr. Lord, in his account of the Geology of Afghanistan, mentions the existence of an enormous band of black roofing slate

[1] Mem., G. S. I., Vol. XVIII, p. 150.
[2] Administration Report, Central Provinces, 1866-67, p. 80.
[3] Berar Gazetteer, p. 27.
[4] Page 85.
[5] Mem., G. S. I., Vol. XII, p. 262.
[6] *Op. cit.*, Vol. VI, p. 217.

which he says extends from Attock to the longitude of Bamian, 100 miles west of Kabul.[1]

Punjab: Simla and Gurdaspur Districts.—According to Mr. Medlicott[2] the variety of slate obtained along the flanks of the Dhaoladhar and used at Dalhousie and Dharmsala has proved of first-rate quality for roofing purposes. It is readily fissile, dresses well, and can be obtained of considerable size. It is a highly silicious rock of pale-gray colour, and is not so fine as ordinary slate; it is therefore inapplicable to some of the purposes to which the latter is put. A sample of Dalhousie slate, exhibited at the Lahore exhibition, was 12 feet long and 4 or 5 feet wide.[3]

The slate, which is extensively used at Simla, is in every way inferior to that from the Dhaoladhar. In Jaunsar[4] and other parts of the hills there are also slate quarries. Slates are also obtainable in Attock, Abbottabad and Spiti.

Gurgaon District.—In a special paper on the slate quarries of this district, Mr. Crawford Campbell[5] has described the principal localities as they appeared in the year 1867. They are situated at Pali, Maneti, Rewari, and Papri near Petungura. The quarries at Maneti were considered to contain the best roofing slate. How far Mr. Campbell's suggestions have been acted upon, or how far the slate has proved equal to the high quality he ascribes to it, is not known.

North-West Provinces: Kumaun: CHITELI.—At this locality there is a quarry from whence some slate was raised with which it was proposed to roof buildings at Ranikhet and elsewhere. It is a distinctly laminated slate, and is coarser, heavier and more silicious than Welsh slate. Slabs of a foot square and quarter inch thick are obtainable easily and in abundance.[6] But the quarries were not being worked in 1877, so that the demand must be small.

Mr. Atkinson[7] states that there are slates to be had at Dhari in the Bel Patti of Gangoli, in Borarao Patti, Sult Patti, and in Naini Tal. In Lohba in Garhwal a thin dark-blue slate is procurable, but it is apparently inferior to that at the Chiteli quarry.

[1] Indian Review, Vol. III, p 315.
[2] Mem., G. S. I., Vol. III, Pt. II, p. 176.
[3] Punjab Products, p. 56.
[4] Blane, Captain. Trans. Roy. As. Soc., Vol. I, p. 61.
[5] Professional Papers on Indian Engineering, Vol. IV, p. 257.
[6] Hughes, T. W. H. Records, G. S. I., Vol. III, p. 43.
[7] Economic Mineralogy of the Hill Districts, Pamph., Allahabad, 1877, p. 36.

Darjiling District.—It has been supposed that a good roofing slate could be obtained in this district, but the best pieces seen by Mr. Mallet[1] were not more than a few inches in length and quarter inch thick, besides which the material is too brittle to trim well on the edges. Flagstones for flooring purposes could probably be obtained in some localities.

[1] Mem., G. S. I., Vol. XI, p. 90.

CHAPTER XVI.

MISCELLANEOUS.

LITHOGRAPHIC STONES—General Remarks—Madras—Bellary—Karnul—Bengal—Behar—Rewah—Central Provinces—Raipur—Rajputana—Jesalmir—Bombay—Kaladgi—Punjab. MILLSTONES—Genaral Remarks—Bengal—Behar—Bombay—Kaladghi—Cutch. GRINDSTONES—General Remarks. POTTERY CLAYS AND KAOLIN—General Remarks—Madras—Trichinopoli—South Arcot—North Arcot—Chingleput—Mysore—Mangalore—Orissa—Bengal—Colgong—Bardwan—Rajmahal Hills—Farrukhabad—Bombay—Sind—Punjab—Darjiling—Assam—Burma. FIRE CLAY—General Remarks—Bengal—Raniganj—Burma. BRICK CLAYS—General Remarks. FULLER'S EARTH—General Remarks—Bengal—Bhagulpur—Rajputana—Ajmir—Bikanir—Bombay—Sind—Punjab—Dera Ghazi Khan—Multan—Salt Range. SOILS.—General Remarks.

Lithographic Stones: General Remarks.—Limestones suitable for lithographic purposes are not of wide distribution; the combination of qualities requisite are not often found united. The best stones are compact and uniform in texture, and are free from veins, flaws, and spots; they are generally of light colours, for although stones of dark colour can be used for certain purposes, for others it is necessary that the lithographer should have a light ground to work upon.

At present the principal supply of the world is obtained in quarries in the oolitic rocks of Solenhofen near Munich, and in Pappenheim on the Danube.[1]

The introduction of lithography into India is claimed by Mr. T. N. Rind[2] to have been accomplished by him in 1822. He was afterwards put in charge of the Government Lithographic Press. Its applicability to the reproduction of native writing, where types were not available, led to its extension and wide adoption all over the country, and the number of presses, the majority of which are worked solely by the natives, must be very considerable at the present moment. The great cost of stones imported from Europe early led to trials being made of stones of indigenous origin, which it was hoped would supplant the European stones; and it seems probable that the idea which was at one time held by Indian geologists that the Vindhyan rocks were of liassic age served to encourage the hope that a suitable material would be found. As a

[1] Economic Geology by D. Page, p. 222.
[2] Gleanings in Science, Vol. 1, p. 295.

matter of fact, most of the limestones which were tried belonged to some one or other of the more or less altered series of transition rocks. They proved to be, even when consisting of nearly pure carbonate of lime, hard and splintery, and some of them contained free silica. They are difficult to dress and polish, and though some of them were shown to suit well for simple transfers of writing, &c., the fact that they are not used, at least to any appreciable extent, while high prices continue to be paid for European stones, is the strongest argument against their being of any substantial value. The jurassic and younger rocks of Jesalmir, Cutch, and the Punjab may include a suitable material, but there is not much prospect of one being found elsewhere.

Madras.—Limestones suitable for lithographic purposes are said to have been obtained in several of the districts of the Madras Presidency, namely, in Bellary, Karnul, Guntur, and Masulipatam.[1]

Bellary.—In the year 1827 a sample of stone from Bellary was reported upon by Colonel Garrard as being fully as suitable as, if not even superior to, those which had hitherto been exclusively obtained from Germany. In the only other notice of this rock it is stated, however, that the presence of quartz crystals renders it unsuitable for lithographic purposes.

Karnul District.—Stone obtained in the valley of the Tungabhadra was also reported on by Colonel Garrard, who stated that it was harder than the German stone, and that if suitable ink were used, impressions nearly equal to copper-plates could be obtained; subsequently stones for numerous publications were used by Colonel G. R. Jervis of the Bombay army, and were said to answer admirably.

The stones from Dachepalle in Guntur and Jagiapetta in Masulipatam were also favourably reported on; and Dr. Balfour[2] mentions a limestone from a hill near Dyda in the Palnad, as being suitable for lithographic purposes.

In all these localities the limestones belong to the more or less metamorphosed Kadapah or Karnul series, and they are therefore harder, more splintery, and less tractable than the European stone. Doubtless they might answer for some purposes, but they would be difficult to trim; it might even be necessary to saw them into shape.

Bengal: Behar: ROTASGARH.—The limestones of the Lower Vindhyan series attracted attention at an early period[3] as possibly affording a suitable material for lithography, but they are not sufficiently pure

[1] Selections from Records, Madras Government, No. II, p. 38.
[2] *Op. cit.*, Vol. XXIX, p. 80.
[3] Gleanings in Science, Vol. I, p. 55.

and homogeneous to be depended on, and are moreover of dark colour, and are also too thin.[1]

Rewah.—Some very small samples, of apparently the same age as the above, were forwarded in 1843 by Captain Shortrede from Boorwa, 2 miles south-east from Raipur, which is 12 miles from Rewah on the road to Mirzapur. They were favourably reported on by Mr. Black of the Asiatic Lithographic Press, who, however, asked for larger samples, which it does not appear that he ever received.[2] Further research in this region was made by Captain Stewart in the year 1844, and samples were tried in the lithographic press at Allahabad, but the results appear to have been unfavourable.[3]

Central Provinces: Raipur District.—Stones of a serviceable kind have been found in Raipur, and in 1866 they were being used at the Raipur Jail Press.[4] These stones were doubtless also of Lower Vindhyan age.

Rajputana: Jesalmir State.—Of all the suggested substitutes of indigenous stone for that imported, a yellow limestone obtained in the Jesalmir State appears to have been of greatest promise. It is now over fifty years since attention was first directed to it by Captain Boileau,[5] who was one of the first of the long list of military men who have interested themselves in the mineral resources of the country, and who have contributed so many important papers to the literature of the subject.

A very full account of this stone is given in the Gleanings in Science,[6] and a very fair sample of printing from it is reproduced. It is stated that it was not suited for fine chalk drawings, but could be used for all other purposes with the ordinary materials. The chief point dwelt upon is the method of polishing which it was found necessary to adopt. This was a more elaborate process than the one necessary in the case of European stones; it appears to have been caused by the difference in composition, while the latter are argillaceous limestones; the Jesalmir stone had, according to Mr. Prinsep, the following composition :—

Calcium carbonate	97·5
Yellow-earth resembling bole	2·5
	100·0

[1] Mallet, F. R. Mem., G. S. I., Vol. VII, p. 113.
[2] Jour. As. Soc. Bengal, Vol. XII, pp. 1027 and 1121.
[3] *Op, cit.*, Vol. XIII, p. 60.
[4] Administration Report, Central Provinces, 1866-67, p. 80.
[5] Gleanings in Science, Vol. I, p. 55; and Indian Review, Vol. III, p. 4.
[6] *Idem*, p. 107.

Moreover being in a semi-crystalline condition it was hard and brittle, and hence arose the difficulty in producing a uniform polished surface; the ordinary *sleek stone* and pumice were not capable of effecting this, and accordingly rubbers of lac and corundum, coarse, medium and fine, had to be employed; the actual polish was given with calcined peroxide of tin.

Bombay: Kaladgi District.—In the limestones of the Kaladgi and Bhima series, which are the local representatives of the Kadapah and Karnul rock beds at Bagalkot and Talikot, certain beds supposed to be suitable for lithographic purposes, attracted the notice of Captains Newbold and Aytoun, and other early observers. They were tried both at Madras and Bombay, and the results were not satisfactory. According to Mr. Foote, no demand has arisen for them.[1]

Punjab.—According to Mr. Baden-Powell, indigenous lithographic stones are in use in the Punjab, but they are somewhat soft, and where great sharpness of delineation is required European stones are preferred. The latter are sold at high prices by weight, so that the discovery of a really good stone would be of great value.

It would seem, judging from the geology, that in the Salt-range and in Cutch, there are better chances of finding a limestone suitable for the purpose than anywhere else in India.

In one of the early accounts a lithographic stone from Thibet is mentioned, while it is by no means improbable that a suitable material might be found there; the example referred to was merely a piece of slate or schist with letters cut in relief, and which was supposed to have been used as a printing block; not improbably it was merely one of those pieces of stone with the mystic Buddhistical '*Om*' inscription, which are familiar to all travellers in the Himalayas.

Millstones: General Remarks.—The usual conception of a millstone is that it should be a hard, tough, coarse, silicious sandstone or grit, and these characters have become perpetuated in the term millstone grit, which has been conferred upon a group of rocks underlying the coal-measures. In the absence of sandstones or grits many other rocks, such as quartzites, gneiss, granite, and trachyte, are used, and this is particularly the case in India owing to the cost of carriage of the best stones to distant points. As a general rule within the rocky tracts of India the natives, if they happen to belong to those sections of the population who use ground meal, have shown considerable intelligence in selecting the

[1] Mem., G. S I., Vol. XII, p. 265.

material best suited for the purpose, and rude quarries, which have been worked from time immemorial, are generally to be found in such regions.

Where hard and tough rocks are not to be found, softer ones are used, with the natural result that the meal or flour when ground contains a greater or less amount of grit and dust.

Information regarding the actual sources where millstones are obtained in the different districts of India is very incomplete, but as the subject is one of very minor economic importance, this does not very much matter.

As a rule factories at the Presidency towns import the millstones they require from Europe, and it will be long before India will produce anything equal to the Burrstones, which have to a great extent superseded the ordinary millstones.

Excluding the inferior qualities of millstones made from gneiss, granite, &c., the oldest rock which is used for this purpose is a kind of arkose or grit, which occurs in the older transition rocks. The Vindhyan series affords a variety of materials of different degrees of density and texture. Among the Gondwana rocks the Barakar grits are perhaps the most largely employed, and in many of the coal-fields they are quarried rudely at the surface for this purpose.

Bengal: Behar: Kharakpur hills: JUTKUTTIA.—A quarry has been worked for many years at this locality in a bed of coarse arkose, which presents some resemblance to the true millstone grits, but the origin of its component minerals from crystalline rocks is more directly and prominently apparent.

The bed is of considerable thickness, and being in a vertical position and much jointed it can be readily worked. It is believed that stones cut here supply a considerable area in Monghyr and the adjoining districts, but the trade is apparently not an extensive one.

Bombay: Kaladgi District.—Some very thick-bedded sandstones of the Kaladgi series, which are seen at Gudur, Parvate, and Guldegudd and elsewhere, appear to be thoroughly well suited for the manufacture of large millstones, according to Mr. Foote,[1] who recommends an experimental trial of them.

Cutch.—Mr. Wynne[2] alludes to several rocks in Cutch which furnish tough millstones. They are silicious grits, which occur both in the jurassic and sub-nummulitic groups, and a very similar rock of nearly black colour is found in the tertiary beds at Karimori hill; they are also obtained near Chundeeya, west of Anjar.

[1] Mem., G. S. I., Vol. XII, p. 262.
[2] *Op. cit.*, Vol. IX, p. 91.

Grindstones: General Remarks.—This term is generally applied to sandstones of homogeneous texture, but of which there are different degrees of coarseness according to the purpose for which they are required; not only are they employed for setting and sharpening tools, but for cutting glass and stones, &c. Under the more general term of grinding materials are included such substances as corundum, &c., which are generally used for special purposes when the highest degree of hardness is required, but in some parts of India hones made of a mixture of lac and corundum are used for very ordinary purposes, such as sharpening carpenters' and farriers' tools. These hones are indeed in some respects similar to the patent knife-sharpeners which have of late years been introduced from America.

A very complete list of materials for grinding, sharpening, and polishing, which occur in Southern India, was drawn up some years ago by Dr. Balfour, but regarding the rest of India there is little information available. As yet the indigenous sources of supply have been little drawn upon in European factories and government establishments.

In villages situated in the rocky tracts of India the villagers have generally some favourite rock *in situ* of the most suitable character which the neighbourhood affords, where they sharpen their tools and weapons. Not a few travellers, on seeing the grooved surfaces produced thereby, have been puzzled at first sight to account for them.

Pottery clays and Kaolin: General Remarks.—Information regarding the pottery clays of India is far from complete. The resources of the country in this respect have been but little availed of by the natives, who, as is well known, are little acquainted with the higher branches of the potter's art. There is in fact practically no demand in India, beyond the limits of the larger towns, for any but the very coarsest descriptions of earthenware; these, together with vessels of metal, stone, and temporary platters of leaves, supply all that is required for the culinary arrangements of all but a very small fraction of the inhabitants of Northern India. The coarse earthenware vessel, which costs but a trifle, can be broken after using, and the vessels of metal and stone can be purified by fire. This being so, there is no great prospect of glazed pottery being used extensively in India until caste superstitions and ideas about defilement have been swept away. There is probably no part of the world, not excluding remote oceanic islands, where the use of glazed pottery is less known than is the case in many parts of India. In parts of Madras the large Native Christian population affords, however, a limited market for such wares; and they are also used to some extent by Mahomedans.

The coarse earthenware above alluded to is made of clays which contain so much iron and lime that at a moderately high temperature they are fusible. Sometimes pottery is made from a black clay containing much organic matter, and such vessels are capable of sustaining higher temperatures, but are apt to warp and crack. As a substitute for glaze on ordinary ware, mixtures of fine clays which adhere after heating are sometimes used, but they are rather of the nature of paints than true glazes, being soft, and they are easily scratched with a pin. Of this nature is a composition used in Bengal on the earthen vessels used by sugar-boilers. This shows a capability on the part of the natives for evolving a process which is capable of providing them what is just barely sufficient for their actual requirements but no more.

Articles of glazed pottery, which possess considerable merit from an artistic point of view, are produced in a few widely separated localities in India, the principal of these being Madura in Southern India, Sind in Western India, and in the Punjab. The artistic merits of the productions from these several areas have recently been discussed by Dr. Birdwood, to whose work[1] the reader is referred for details; but the following is a *résumé* of information as to the principal varieties of fancy pottery made in India. "Red earthenware of Travancore and Hyderabad, in the Deccan, the red glazed pottery of Dinapore, the black and silvery pottery of Azimgarh in the North-West Provinces and Surajgurha in Bengal (Bhagalpur), the imitation *bidri* of Patna and Surat in Guzerat, the painted pottery of Kota in Rajputana, the gilt pottery of Amroha, also in Rajputana, the glazed and unglazed pressed pottery of Madura, and the glazed pottery of Sindh and the Punjab."

Trichinopoli District.—The cretaceous rocks of Trichinopoli yield, according to Mr. H. Blanford,[2] several fine clays well adapted for the manufacture of pottery. No use of these is made by the natives whose sole idea here, as in most other parts of India, is to manufacture pottery out of a coarse ferruginous clay. Felspar and kaolin are obtainable in different parts of the district; the former might be obtained from the granitic ridge north of the Cauvery free from quartz and in considerable abundance. A pipe clay, which when ground and kneaded works well, forms a thick bed between Terany and Kauray.

South Arcot District.—"In the South Arcot district a fine plastic clay occurs in the Cuddalore beds near the south bank of the Guddalum, opposite to Punrutti, and is exposed in the road leading southward from that place. It contains small quantities of lime and iron, the latter giving

[1] Industrial Arts of India, p. 135.

[2] Mem., G. S. I., Vol. IV, p. 211.

it a pinkish tint, which becomes darker on burning. It is soft and extremely tenacious."

North Arcot.—The granitic rocks of this district are decomposed to a certain extent, and would yield a certain but, in Mr. Foote's [1] opinion, not a very considerable supply of kaolin. The decomposition does not descend to a great depth, the kaolin is much stained by infiltration of ferruginous matter from lateritic soils above, and a supply of pure water for washing, free from saline matter, would be difficult to obtain. White goblets are manufactured in Arcot and enjoy some reputation,[2] but the source of the clay is not known.

Chingleput District.—The beds of the Rajmahal series afford inexhaustible supplies of very fine pottery clays, more especially at Sripermatur, and in the valley of the Attrampakkam nala.[3] From the beds exposed at Coopum near Perumalput, a supply has been taken for the use of the School of Arts in Madras, where some very good pottery was turned out under Dr. Hunter's direction. The natives make no use of these clays.

Mysore State.—Forty years ago Captain Campbell drew attention to the kaolin earth of Mysore, which he stated extended from Bangalore to Nandydrug. When mixed with equal weights of pounded quartz Captain Campbell [4] found it possible to make with it crucibles which stood well, and were but slightly affected by a heat sufficient to fuse cast-steel.

Other clays are apparently not abundant, and such ware as is made in Mysore, though skilfully manipulated, is brittle from not being subjected to sufficient heat. It is considered that if these clays were mixed with the kaolin and properly used, much improvement would follow. Specimens of a white clay are said to have been favourably reported on by Mr. Minton, but the others were too impure to be of much value; the former has been manufactured into cornice bricks and mouldings, &c.[5]

Mangalore District.—In the year 1841, Dr. Christie [6] discovered in association with the laterite, a few miles to the north of Mangalore, an extensive deposit of what he conceived to be a pure porcelain clay resembling that of Limoges in France, and from which the Severes China

[1] Records, G. S. I., Vol. XII, p. 207.

[2] Campbell, Capt. J. Cal. Jour. Nat. Hist., Vol. II, p. 280; Balfour's Cyclopædia, *Art.*—Pottery.

[3] Foote, R. B. Mem., G. S. I., Vol. X, p. 132.

[4] Jour. As. Soc. Bengal, Vol. X, p. 163.

[5] Mysore and Coorg Gazetteer, Vol. II, p. 4.

[6] Jour. As. Soc. Bengal, Vol. X, p. 967.

is made. There does not appear to be any more recent information as to this deposit.

Orissa—In the rocks of Rajmahal age, at Kukkur and Naraj, on the Mahanadi, beds of white clay occur, which would very probably afford a suitable material for pottery. These clays are used by the natives for ornamenting their houses and dressing leather.

At various places under the coastal laterite beds of lithomarge occur, some of which are fairly white, but others are stained by percolation of ferruginous matter from above. Such a bed is to be seen at Midnapur under Gop house.[1]

Bengal.—In the year 1839 the Honourable Court of Directors forwarded a despatch regarding the heavy expense incurred in supplying articles of common earthenware from Europe, especially to the Medical Department, and directed that an attempt should be made to procure an efficient substitute in India. The improvement of native pottery was to be the chief object in view in any experiments which might be undertaken. The experiments were undertaken by Dr. O'Shaughnessy at the laboratory of the Medical College in Calcutta, and are fully set forth in the report and correspondence published by him.[2] The clays operated on had been received from Colgong, Rhotasgarh, Maulmain, Madras, and Singapur, the last being the best. Various trials as to the most suitable glazes were tried, the best proving to be one consisting of borate of lime.

The varnish or imperfect glaze, which has been above alluded to as being used for the sugar-boilers' pans, known as *kolas*, is thus described by Mr. Piddington. There are two kinds of earth used, one of which is called *belutti*; it is a silicious and ochreous earth, the best being found 8 or 9 *coss* from Kulna. By levigation it is prepared for use, the process lasting, it is said, 15 days. The other earth is called *ooporomee* and is a tenacious loam. The best was obtained at Monad, 10 *coss* west of Chinsurah, and at Panchdowki, 8 *coss* south-west of Kulna. Its preparation is said to take three months, and only 10 seers are obtained from one maund of the earth; two varieties of this *ooporomee* are *gad* and *majaree*. Successive layers of mixtures of *gad*, *belutti*, and *ooporomee* are smeared on the sun-dried common red ware, which is then burnt and glazed at one firing. This varnish is capable of resisting great heat and a very penetrating solution like that of sugar.

Rajmahal Hills.—In several parts of the Rajmahal hills there are beds of white silicious clays belonging to the Barakar coal-measures,

[1] Mem., G. S. I., Vol. I, p. 279.

[2] Bengal Dispensatory and Pharmacopœia, p. 700.

which are suitable for the manufacture of many articles of hard pottery, and which with proper treatment would afford suitable material for fire-bricks. This clay is white with slightly pinkish tint, and burns to a creamy white; by the addition of a more tenacious clay it can be made suitable for higher qualities of pottery.[1] The supply at Patharghata on the Ganges, at Lohandia and several other localities, is practically inexhaustible; pottery works have from time to time been in operation at Patharghata for the manufacture of drainage pipes, &c. In the younger rocks of the Rajmahal group certain clays, called *khari* by the natives and which are used by them as pigments, would also probably yield useful materials for pottery. According to Buchanan the potters of Rajmahal used this *khari* for giving a white surface to pottery made of ordinary clays.

Colgong.—Clay from this neighbourhood, which was reported favourably upon by Dr. O'Shaughnessy, is of the same age and character as that at Patharghata; by admixture in the proportion of 4 to 1 with a sort of fuller's earth called *sabun mitti*, which is also found there, a clay yielding pottery which possessed strength, hardness, density, and infusibility was obtained. Not only was beautiful biscuit-ware made from it, but also admirable fire-bricks, crucibles, &c.

Further to the west in the Ganges valley, at Monghyr, Chunar, Azimgarh, &c., black pottery is manufactured from clays obtained from the alluvium. Sometimes the clay itself is of dark colour, sometimes a wash or varnish is applied to the pottery before baking, but the principal source of the blackness is the smoke which arises from oil-cake thrown into the kiln when the baking is completed. The ornamental objects manufactured at these localities are generally adorned with rude devices, which are produced by rubbing an alloy of tin and mercury into etched surfaces. Some of this pottery is intensely brittle, and is therefore not suitable for rough usage.

Bardwan District: RANIGANJ.—At Raniganj there is a pottery, which is unique in Bengal at the present moment, and, so far as is known to the contrary, in the whole of India, in being the property of a European Company and in being carried on according to European methods. It has proved the means of demonstrating the applicability of many varieties of clay obtainable in that vicinity to the manufacture of earthenware of various qualities, and also of fire-bricks, tiles, drainage pipes, &c.

The clays which are used are chiefly obtained from the coal-measures in the neighbourhood, and consist of more or less decomposed shales; a

[1] Oldham, Dr. T. Jour. As. Soc. Bengal, Vol. XXIV, p. 281.

white lithomarge is obtained under laterite at a point about 12 miles north-east of Bankura. A certain amount of kaolin would be obtainable from this area, but to what extent it has been collected is not known.

Farrukhabad District: FATHEGARH—About the year 1838 Mr. Julius Jeffreys[1] established pottery works at Fathegarh, which, in so far as the articles manufactured was concerned, attained a very considerable degree of success. From the varied nature of the articles manufactured it is apparent that a considerable variety of materials were available, and that the operations were under skilled management. Besides a variety of ordinary stoneware, fire-bricks, fire-tiles, glazed tiles, &c., &c., were produced and were most favourably reported on.

Bombay: SIND.—The glazed pottery of Sind is made principally at Hala, Hyderabad, Fatta and Jerruck, and the encaustic tiles at Bulri and Saidpur, according to Dr. Birdwood, in whose volume the manufacturing details will be found. With regard to one of the raw products, the oxide of cobalt, which is used for producing the rich blues, it may be said that its occurrence in India is not so widespread as is sometimes supposed, being in fact limited to certain mines in Rajputana (see page 324).

Punjab.—According to Mr. Baden-Powell, the pottery clays of the Punjab principally consist of a grey clay which burns red; there are also, however, clays which burn to a yellowish white or cream colour; these are obtained in Dera Ghazi Khan, Dera Ismail Khan, and Kohat. As yet no material suitable for terracotta has been obtained. The subject of bringing down kaolin from the decomposed granite in the Himalayas has been discussed, but the cost of carriage has been found to be too great. Very full details of the different classes of pottery manufacture, as practised in the Punjab, will be found in Mr. Baden-Powell's works.[2]

Delhi District.—There are kaolin mines at Kussumpur; and a short distance to the south of it in the Delhi hills, north of the Kutub minar, they consist of pits sunk in dykes of decomposed granite. By levigation the quartz and mica are removed, and the kaolin is pressed into cakes, and is chiefly used for whitewashing, but also possibly for ceramic purposes. Another mine is situated at Buchara near the Lota river in the Alwar hills.[3]

Darjiling.—Some of the beds in the Daling series decompose into a white clay, which Mr. Mallet[4] considers would be suitable for pottery. There is a quantity of this material near the right bank of the stream

[1] Cal. Jour. Nat. Hist., Vol. II, p. 593; and Vol. III, p. 152.
[2] Punjab Products and Punjab Manufactures.
[3] Records, G. S. I., Vol. XIII, p. 249.
[4] Memoirs, G. S. I., Vol. XI, p. 90.

at the debouchure of the Sakkam river. A similar material is said to be used in Sikkim for whitewashing.

Assam.—It may be of interest to state that there are two independent references to an apparently considerable deposit of pure kaolin, which is found in one or more localities in the extreme north-east of Assam. The first mention is by Mr. Bruce,[1] who gives the locality as Bhramakhund. The second is by Colonels Dalton and Hannay,[2] who mention the Dora stream, which is a few miles below Parghat, 8 miles below Bhramakhund. Four miles up the stream a thick deposit was found, which rested upon white quartz, and had apparently been deposited by the river. It is termed *rukmani-pitha* by the natives. There can of course be no immediate prospect of this distant source of supply being drawn upon; but the fact is worthy of record. A fine white clay, apparently of good quality for pottery, occurs very extensively near the base of the cretaceous rocks at the western end of the Garo hills.[3]

Burma.—According to Mr. Theobald,[4] the ordinary alluvial clay of the province, mixed with water and sand, affords the material for ordinary pottery and bricks; but a dark-coloured seam in the Irawadi valley is much sought for by potters. Some of the upper beds in the nummulitic group are said to consist of China clay, and would answer well for pottery on account of their freedom from iron. Kaolin is found in several parts of Tenasserim,[5] as might be expected, being derived from the extensive decomposition of the granite which has yielded the tinstone. Several deposits, believed to be of considerable extent, are situated on the banks of the Great Tenasserim river.

"In the neighbourhood of Bassein and of Bheelang on the Sitang (Tsittoung), excellent clay is found and worked into highly ornamental vessels, whilst Gnyoung-beng-shiep near Maulmain, and Twante and Kwon-Khyan-goon in Rangoon, are noted for their jars and pots." The Bassein pottery has a tracery applied in relief, and consists of grotesque figures of plants and men, &c.

Coarse forms of pottery for salt-boiling and for domestic purposes are largely manufactured in many districts as required from the local alluvial clays.

Fire-clays: General Remarks.—Fire-clays derive their name from their refractory nature,—that is to say, from their capacity to resist very high temperatures, without fusing, fissuring, or alteration of shape:

[1] Jour. As. Soc. Bengal, Vol. II, p. 438.
[2] Mem., G. S. I., Vol. I, p. 91.
[3] Records, G. S. I., Vol. VII, p. 61.
[4] Mem., G. S. I., Vol. X, p. 341.
[5] Gazetteer of British Burma.

The essential qualities of ordinary fire-clays are that they should be as nearly as possible free from lime, iron, and alkaline earths, all or either of which promote the fusion of silica.

Highly refractory bricks, for special purposes, have been made from aluminous dolomites, but in the ordinary fire-clays silica and alumina, in the proportion of nearly 3 to 1, are the principal constituents, alkaline earths and combined water being the principal other solid constituents; hygroscopic water, often exceeding 10 per cent., is present.

Although it may be possible to build houses with bad or indifferent bricks, it is quite impossible to carry on many metallurgical and other processes continuously without the aid of durable and refractory fire-bricks; great damage may be caused to valuable machinery by the failure of inferior bricks to resist high heat; attempts at economy in that direction, therefore, may cause serious loss. Hence it is that fire-bricks with known brands have been largely used in India, in spite of their high price.

In view of the rapidly increasing number of manufactories in this country, in which fire-bricks and crucibles are largly employed, it is obvious that the production of perfectly trustworthy fire-bricks is of not inconsiderable importance.

In England the best source of fire-clay is the floor or under-clay, which is frequently found underlying coal seams, and in India similarly situated clays appear also to afford the best material. It is probable that, with proper manipulation, some of the pottery clays mentioned on previous pages would afford perfectly refractory materials. Such was found to be the case with the Colgong clay experimented on by Dr. O'Shaughnessy; the bricks and crucibles which were manufactured from it were considered to be equal to the articles imported from Europe. English fire-bricks cost then (1840) in Calcutta, Rs. 10 a hundred, while it was estimated that with the Colgong clays bricks could be made, with a fair margin of profit, for Rs. 2-8 a hundred. The chief localities where fire-bricks have been made in India are situated in the coal-fields.

Raniganj.—For some years back, at the Bengal pottery belonging to Messrs. Burn and Company, efforts have been directed to the production of thoroughly refractory fire-bricks, and it is believed that these efforts have met with a considerable degree of success. Some samples were subjected to very severe tests at the Calcutta Mint in 1875; although they had answered well in ordinary cupolas, the tests were applied in order to ascertain whether they would stand the more heavy work of a blast-furnace. The trials were made under the supervision of Messrs. H. B. Medlicott and T. W. H. Hughes[1]; the first results were not

[1] Records, G. S. I., Vol. VIII, p. 18.

completely satisfactory, but subsequently, after certain defects in the manufacture had been removed, the bricks stood the tests perfectly, showing no sign of cracking or vitrification. Subsequently these bricks were used in the blast-furnaces of the Bengal Iron Works Company, and, it is believed, proved satisfactory.

The principal material used in their manufacture was a slightly carbonaceous under-clay obtained from the coal-field, but other materials in or in the neighbourhood of the field were also employed. In the Karharbari coal-field, fire-clays have been found in the coal-measures, and have been used in the manufacture of bricks for cupolas, furnaces, coke ovens, &c. At Barwai fire-bricks were made, but as the iron works were closed before the manufacture of iron commenced, they can scarcely have been properly tested.

Promising-looking fire-clays are found in the Chanda or Wardha coal-field.[1]

Burma: MAULMAIN.—A fire-clay, believed to be of good quality, is found near Maulmain.[2]

Brick-Clays: General Remarks.—Since the time, in the early part of the century, when it was thought necessary to import bricks into India from England, the fact has come to be generally admitted that clays, suitable for the manufacture of bricks, are to be found in most parts of the country. This discovery was, however, scarcely a new one, since there are in many regions in India buildings in which bricks, some of very large size, have been used, and which are known to be of high antiquity.

As a rule Indian-made bricks do not bear a very high reputation for strength or durability; but it has been demonstrated that good bricks can be made, and it seems probable that in many cases where the bricks are bad, the system of manufacture, rather than the material, is to blame. Of course there are some clays so impregnated with lime kankar nodules that without grinding they are inapplicable to the manufacture of good bricks. In the neighbourhood of most of the large rivers in India clays are, however, to be found tolerably free from these impurities.

The largest brick factory in India is situated at Akra near Calcutta, where from 20 to 30 millions of bricks are turned out annually. This factory belongs to Government, and the bricks are supplied to the departments at fixed rates, and at somewhat higher rates to outsiders.

Most of the accounts of brick-making in different parts of India

[1] Mem., G. S. I., Vol. XIII, p. 114.
[2] Cal. Jour. Nat. Hist., Vol. II, p. 596.

are made up of technical details regarding the manufacture, and there seems to be little information of a character suitable for reproduction here.

Fuller's Earth: General Remarks.—Being of detrital origin fuller's earth does not possess a definite chemical composition, but in general terms it may be described as a soft unctuous silicate of alumina. It derives its name from having been used in the 'fulling' of woollens; though it is still largely employed for this purpose other detergents are now more generally used. In India, fuller's earth is employed in the washing of cloths which are used in the manufacture of lac, indigo, &c., and doubtless for many other purposes. It is believed that earths of this nature afford the principal part of those which are used as a comestible. The practice of earth-eating is widespread over the world, and though there is not much information available on the subject, in reference to India, the fact is known that these edible clays from different localities are to be had in most Indian bazaars, and it seems possible that the practice of eating them is not limited merely to pregnant women, as is sometimes stated.

The probability is that, once acquired, the habit is not easily given up. Saucer-shaped chips, about 2 inches in diameter, of partially baked clay, for eating, are sold in the Calcutta bazaar; they are said to be made by potters a few miles to the north of Calcutta.

As to the distribution of fuller's earth in India the information is very incomplete; but it is known to be carried for long distances from certain localities where it does occur. It does not appear to be mentioned in any of the accounts of Madras. Heyne[1] mentions having found some in Hyderabad, but gives no particulars.

Bengal: Bhagalpur Division.—As already mentioned in connection with the *khari* or pottery clay of Colgong, a *sabun miti* or soap-earth is obtained in that neighbourhood. Under the name Rajmahal *mitti* a comestible earth is sold in the Calcutta bazaars, the precise source of which is not known.

Rajputana: Ajmir District.—According to Dr. Irvine[2] a fuller's earth used to be obtained near Ajmir in fissures of quartz and schistose rocks with carbonate of lime.

Bikanir State.—In the Gazetteer[3] of Bikanir, Major Powlett states that the *multani mitti* or fuller's earth, which is excavated at the village

[1] Tracts, p. 273.
[2] Topography of Ajmir.
[3] Page 97.

of Meth near Kolath, gives employment to 25 persons, who receive three annas a camel-load, while the State takes Rs. 1-8. It is said that about two thousand camel-loads are taken away in the course of the year, but Major Powlett thinks this may be an under-estimate, as in two days he met seven or eight hundred camels laden with the *mitti* on their way to Sirsa, where it sells for Re. 1 a maund.

Bombay: Sind.—In some parts of Western Sind, according to Mr. W. T. Blanford,[1] a pale-greenish clay is found which is used for washing cloth, &c. It is also eaten by pregnant women.

Punjab: Dera Ghazi Khan and Multan Districts.—According to Captain Pollock, 10,000 maunds of a clay resembling fuller's earth is imported annually from the interior of the Suleman range; it is used for the same purposes.

With reference to Multan, Lieutenant Corbyn writes that the so-called *multani mitti* is not produced in Multan itself, but three qualities are imported as follows:—

(1).—White mitti, called *khajru* or edible, from Bikanir and Jesalmir, in quantities of 1,000 maunds, value Rs. 1,000.

(2).—Yellow mitti or *bhakri*, used for dyeing clothes, from same localities, in quantities of 1,000 maunds, value Rs. 875.

(3).—Light-green or *sabz-mitti* for cleaning the hair, from Vadur in the Dera Ghazi Khan District, 200 maunds, value Rs. 150.

Salt-range: Nilawan.—A lavender-coloured clay ash or decomposed rock, which is found with volcanic rock at the above locality, is used as fuller's earth by the natives according to Mr. Wynne.[3]

Soils: General Remarks.—To do full justice to so large a subject as this would require a very considerable amount of space owing to the variety of soils and the extent of the areas over which they are spread. Among the agricultural classes of India, numerous sub-divisions of soils are recognised and possess a nomenclature of their own. The differences have a very material influence on the revenue of the country, and hence revenue and settlement officers have had to pay a good deal of attention to the subject, and some of them have discussed it according to scientific methods; but the available information is very unequal; for the most part it is accessible to those seeking for it, in the local Settlement Reports and Gazetteers, so that no useful object would be attained by attempting to give a curtailed abstract here.

[1] Mem., G. S. I., Vol. XVII, p. 195.
[2] Punjab Products, p. 24.
[3] Mem., G. S. I., Vol. XIV, p. 300.

APPEN

Statement of the Quantity and Value of the principal Mineral Productions

Countries whence imported.		1879-80.		1878-79.		1877-
		Quantity.	Value.	Quantity.	Value.	Quantity.
SULPHUR.						
			Rs.		Rs.	
United Kingdom . .	Cwt.	12,034	72,380	20,179	1,26,448	21,726
France	„	...	...	2,741	18,185	283
Arabia	„	769	5,465	748	5,912	909
Persia	„	...	...	809	14,063	1,648
Other countries . .	„	516	3,445	85	299	233
TOTAL .	„	13,319	81,290	24,562	1,64,907	24,799
ARSENIC.						
United Kingdom . .	Cwt.	104	2,006	693	13,718	414
Austria	„	88	1,251	389	5,139	188
China	„	69	1,144	928	14,989	212
Turkey in Asia . .	„	...	...	114	2,630	132
Other countries . .	„	39	865	82	2,244	190
TOTAL .	„	300	5,266	2,206	38,720	1,136
COAL AND COKE (not including Patent Fuel).						
United Kingdom . .	Tons.	513,576	99,42,620	452,326	84,70,057	580,196
France	„	1,226	22,725	...	...	1,000
Germany	„	7,064	1,27,994	3,850	65,560	2,226
Italy	„	3,509	68,639	5,480	1,00,737	597
United States and South America	„	375	4,500	401	6.015	...
Ceylon	„	284	5,183	2,648	45.858	788
Australia	„	49,128	9,05,357	6,993	1,12,213	15,643
Other countries . .	„	3,135	56,667	1,637	28,725	709
TOTAL .	„	578,297	1,11,33,685	473,335	88,29,165	601,159
BORAX.						
United Kingdom . .	Cwt.	34	922	15	340	12
Ceylon	„	...	...	...	...	...
TOTAL .	„	34	922	15	340	12

DIX A.

imported into British India, and the Countries from whence they are imported.

78.	1876-77.		1875-76.		1874-75.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.
1,48,085	20,072	1,40,841	13,264	92,173	5,231	30,819
1,852	...	...	986	5,918	...	...
5,281	549	3,143	386	1,828	...	...
18,235	1,006	15,340	2,196	16,559	3,837	18,060
1,469	707	5,857	2,077	13,998	1,969	11,815
1,74,922	22,334	1,65,181	18,909	1,30,476	11,037	60,694
9,393	65	1,248				
3,164	50	1,014				
3,485	247	4,503	Information	not available	for years pr	ior to 1876-77.
2,470	165	3,583				
2,676	18	365				
21,188	545	10,713				
97,94,557	510,459	91,71,605	370,087	64,64,725	346,109	65,99,387
15,500	1,111	20,589	156	2,520	...	...
30,884	500	7,000	...	...	660	11,880
10,371	421	9,192	241	4,818	...	...
...	2,146	35,660	130	2,215	787	14,715
11,321	552	7,345	676	13,795	4,114	84,029
2,04,370	798	8,670	6,130	82,564	4,652	81,535
12,320	3,592	53,884	1,724	28,935	675	13,081
1,00,79,323	519,579	93,13,945	379,144	65,99,572	356,997	68,04,627
314	146	3,235	11	444	Informatio	n not availablo
...	1	48	...	...	for years pr	ior to 1875-76.
314	147	3,283	11	444		

Statement of the Quantity and Value of the principal Mineral Productions in

Countries whence imported.		1873-74. Quantity.	1873-74. Value.	1872-73. Quantity.	1872-73. Value.	1871- Quantity.
SULPHUR.						
			Rs.		Rs.	
United Kingdom	Cwt.	7,000	40,534	13,218	78,370	14,303
France	"	...	...	4,738	28,420	2,302
Arabia	"	...	...	...	...	...
Persia	"	324	1,460	1,002	4,510	3,999
Other countries	"	261	1,473	134	627	1,017
TOTAL	"	7,585	43,467	19,092	1,11,927	21,621
ARSENIC.						
United Kingdom	Cwt.					
Austria	"			Information not		available for
China	"					
Turkey in Asia	"					
Other countries	"					
TOTAL	"					
COAL AND COKE (not including Patent Fuel).						
United Kingdom	Tons.	336,295	69,01,694	302,190	47,80,548	360,950
France	"	5,676	1,25,523	17,903	1,21,290	454
Germany	"	1,710	32,667	1,613	22,695	5,007
Italy	"	...	...	...	...	...
United States and South America	"	798	13,129	441	7,243	..
Ceylon	"	207	4,566	218	4,518	1,386
Australia	"	14,677	3,09,271	1,511	29,494	5,917
Other countries	"	540	13,413	762	13,629	453
TOTAL	"	359,903	74,00,263	324,638	49,79,417	374,167
BORAX.						
United Kingdom	Cwt.			Information not		available for
Ceylon	"					
TOTAL	"					

ported into British India, and the Countries from whence they are imported—contd.

72.	1870-71.		1869-70.		1868-69.		1867-68.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.		Rs.
87,485								
20,434								
...	Informa	tion not ava	ilable for	years prior	to 1871-	72.		
19,789								
4,784								
1,32,492								
years prior	to 1876-	77.						
49,62,656	274,698	45,22,293	321,419	51,75,599	335,291	69,12,365	377,549	83,69,322
7,140	1,241	14,892	415	5,080	1,512	34,571	...	...
70,260	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	460	5,520	...	...	...	...
17,851	364	4,963	420	9,125	...	...	...	...
85,017	8,942	1,04,692	12,607	2,20,205	9,257	1,82,739	..	...
5,017	936	24,123	1,702	29,246	2,867	28,960	7,782	1,70,516
51,47,941	286,181	46,70,963	337,023	54,44,775	348,927	71,58,635	385,331	85,39,838
years prior	to 1875-	76.						

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1879-80. Quantity.	1879-80. Value.	1878-79. Quantity.	1878-79. Value.	1877- Quantity.
Chalk and Lime (not separately distinguished).						
			Rs.		Rs.	
United Kingdom . .	Cwt.	8,823	8,826	9,903	7,059	53,463
Red Sea	"	...	...	...	...	..
Arabia	"	19,083	5,175	55,835	30,972	17,420
Ceylon	"	...	...	...	...	...
Persia	"	...	...	...	...	...
Other countries . .	"	15,833	5,293	5,258	3,423	1,629
Total .	"	43,739	19,294	70,996	41,454	72,512
Precious Stones and Pearls (Unset diamonds cannot be distinguished).						
United Kingdom		...	1,59,040	...	59,463	...
France		...	7,205	...	1,670	...
Red Sea		...	...	...	...	...
Africa		...	1,070	...	1,380	...
Aden		...	77,475	...	40,395	...
Arabia		...	4,27,850	...	3,76,230	...
Ceylon		...	91,802	...	4,226	...
China		...	58,399	...	79,505	...
Persia		...	6,52,147	...	7,11,550	...
Straits Settlements		...	68,872	...	25,663	...
Other countries		...	8,939	...	14,950	...
Total . .		...	15,52,799	...	13,15,032	...
Saltpetre.						
United Kingdom . .	Cwt.	3	49	...	...	...
Ceylon	"	...	...	...	2	...
Straits	"					
Other countries . .	"					
Total .	"	3	49	...	2	...
Salt.						
United Kingdom . .	Tons.	305,990	66,58,461	231,082	51,39,113	227,345
France	"	3,440	72,003	2,675	37,700	1,974
Germany	"	7,081	1,85,756	4,395	1,02,477	1,921
Italy	"	7,781	1,39,283	7,935	1,26,368	10,254
Mediterranean Ports .	"	...	...	...	...	...
Red Sea	"	...	...	...	...	...
Africa	"	2,073	42,554	3,858	76,995	2,206
Arabia	"	24,587	5,05,088	20,753	3,97,150	9,434
Ceylon	"	..	...	2,050	32,509	...
Persia	"	1,277	21,775	1,419	23,335	1,092
Other countries . . .	"	9	401	13	472	6
Total . . .	"	352,238	76,25,321	274,180	59,36,119	254,231

ported into British India, and the Countries from whence they are imported—contd.

78.	1876-77.		1875-76.		1874-75.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.
13,880	181,794	54,503	27,697	14,238	...	8,137
...	...	...	...	...	...	...
9,898	20,853	11,084	13,250	4,800	...	6,851
...	2,315	1,916	6,431	6,019	...	1,890
...	...	...	...	...	...	5,657
1,063	3,339	913	106	140	...	...
24,841	208,301	68,416	47,484	25,197	...	22,535
34,091	...	75,092	...	29,882	...	44,219
6,850	...	1,900	...	46,400	...	1,820
...	...	...	...	...	...	...
3,140	...	3,400	...	50	...	2,000
25,775	...	16,250	...	33,200	...	30,250
8,20,765	...	6,21,500	...	4,38,950	...	38,025
36,810	...	5,210	...	4,741	...	3,670
37,132	...	93,875	...	69,805	...	84,265
9,31,546	...	7,65,550	...	7,60,050	...	13,68,855
13,581	...	8,090	...	10,513	...	11,790
31,158	...	53,114	...	...	...	11,800
19,40,848	...	16,43,891	...	13,93,591	...	15,96,694
...	...	...	...	...	Information not available for years previous to 1875-76.	
...	13	373	6	107		
...	13	373	6	107		
35,80,053	255,772	36,80,994	306,385	49,71,776	249,957	68,31,884
26,821	4,590	58,794	5,718	86,387	1,241	33,773
42,769	1,471	24,431	1,326	22,245	1,110	32,016
1,85,228	13,619	1,96,327	26,390	5,21,509	...	...
...	...	...	...	...	12,897	3,35,555
...	...	...	...	...	...	...
29,910	4,057	50,871	226	4,715	...	...
1,32,584	16,056	2,10,881	19,261	3,04,660	7,620	2,07,674
...	1,913	26,086	...	...	...	...
16,123	1,293	60,338	3,830	68,064	4,251	1,16,591
167	5	179	2,115	29,987	8	221
40,13,655	298,776	43,08,901	365,251	60,09,343	277,084	75,57,714

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1873-74. Quantity.	1873-74. Vlaue.	1872-73. Quantity.	1872-73. Value.	1871- Quantity.
Chalk and Lime (not separately distinguished).						
			Rs.		Rs.	
United Kingdom	Cwt.	...	46,391	...	28,143	...
Red Sea	"	...	2,817	...	3,338	...
Arabia	"	...	...	...	...	...
Ceylon	"	...	...	...	2,467	..
Persia	"	..	1,900	...	3,450	...
Other countries	"	...	695	...	90	...
Total	"	...	51,803	...	37,488	...
Precious Stones and Pearls (Unset diamonds cannot be distinguished).					Quantity n	ot available
United Kingdom		...	18,465	...	12,346	...
France		...	3,730	...	...	...
Red Sea		...	32,350	...	21,200	...
Africa		...	5,350	..	52,244	...
Aden		...	66,900	...	72,375	...
Arabia		...	...	...	...	...
Ceylon		...	6,663	...	32,250	...
China		...	99,402	...	1,67,975	...
Persia		...	11,04,025	...	13,49,880	...
Straits Settlements		...	47,322	...	55,083	...
Other countries		...	567	...	4,000	...
Total		...	13,84,774	...	17,67,353	...
Saltpetre.						
United Kingdom	Cwt.			Info	rmation not	available for
Ceylon	"					
Straits	"					
Other countries	"					
Total	"					
Salt.						
United Kingdom	Tons.	242,319	73,70,788	233,294	71,15,326	262,448
France	"	1,239	33,717	6,168	1,67,993	1,921
Germany	"	1,301	24,016	1,215	21,555	2,111
Italy	"	...	...	...	...	...
Mediterranean Ports	"	10,383	2,71,755	6,890	1,87,558	2,018
Red Sea	"	16,565	4,50,873	17,367	4,72,781	35,416
Africa	"	...	...	54	1,480	...
Arabia	"	...	...	...	...	...
Ceylon	"	...	...	...	...	178
Persia	"	7,286	2,00,304	10,261	2,79,726	2,457
Other countries	"	122	2,090	1,498	40,611	290
Total	"	279,245	83,53,543	276,747	82,87,030	306,839

ported into British India, and the Countries from whence they are imported—contd.

72.	1870-71.		1869-70.		1868-69.		1867-68.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.		Rs.
21,426	...	23,159	...	26,579	...	26,082	...	Details not available.
2,470	...	7,752	...	5,234	...	13,562	...	
...	...	...	...	...	...	...	...	
6,737	...	6,429	...	5,855	...	2,254	...	
2,182	...	22,277	...	12,813		3,826	...	
1,089	...	2,868	...	1,200	...	611	...	
33,904	...	62,485	...	51,681	...	46,335	...	14,111
for years prior to 1875-76.								
31,607	...	4,186	...	45,573	...	37,470	...	4,550
15,477	...	...	...	...	...	37,690	...	6,311
4,250	...	3,100	...	...	...	...	...	14,950
12,008	...	56,170	...	95,445	...	1,50,154	...	1,06,159
36,750	...	57,880	...	27,900	...	79,450	...	1,03,067
...	...	...	...	...	...	...	...	...
5,270	...	6,070	...	...	...	...	...	1,150
1,01,925	...	1,79,595	...	2,98,400	...	2,06,000	...	1,96,460
14,02,350	...	9,05,090	...	13,96,895	...	9,78,934	...	11,99,125
94,459	...	52,408	...	40,471	...	24,346	...	19,050
10,300	...	3,500	...	10,449	...	250	...	480
17,14,396	...	12,68,899	...	19,15,133	...	15,14,294	...	16,51,302
years previous to 1875-76.								
79,02,253	193,348	62,60,533	237,348	68,32,168	241,685	66,09,252	212,782	62,17,299
52,304	5,830	1,40,982	5,670	61,559	3,337	59,635	3,438	69,462
85,492	4,033	1,07,389	...	...	1,156	52,584	...	...
...	...	...	...	...	...	...	...	...
54,933	...	...	...	...	...	...	...	...
9,63,662	22,701	6,03,277	10,677	1,58,783	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
4,850	1,693	46,088	4,052	28,514	1,428	51,549	3,187	58,766
67,597	...	...	14,962	4,17,404	18,550	4,98,576	25,732	4,23,058
8,058	5	649	109	2,524	140	21,105	147	6,148
91,39,149	227,610	71,58,918	272,818	75,00,952	266,566	72,92,701	245,286	67,74,738

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1879-80. Quantity.	1879-80. Value.	1878-79. Quantity.	1878-79. Value.	1877- Quantity.
Petroleum (Mineral Oils).			Rs.		Rs.	
United Kingdom	Gals.	459,728	3,24,489	358,444	2,86,138	152,725
Austria		...	...	53,965	47,168	116,860
Africa		...	...	21,472	13,879	22,868
America		7,200,154	43,19,023	3,020,310	21,07,907	1,750,628
Straits Settlements		228,004	1,75,096	308,327	2,50,647	233,071
Other countries		361	471	13,156	11,373	129,253
Total		7,888,247	48,19,079	3,775,674	27,17,112	2,405,405
Stone and Marble (Building stones, millstones, grindstones, &c., cannot be distinguished).						
United Kingdom	Cwt.	2,404	24,628	5,855	33,331	16,271
France		...	...	...	...	...
Italy		8,995	61,606	6,451	45,122	14,879
Mediterranean Ports		...	...	...	...	...
Aden		...	...	...	..	...
China		2,200	2,942	863	2,729	935
Straits Settlements		555	1,848	2,915	4,116	745
Other countries		3,269	2,390	582	648	52
Total		17,423	93,414	16,666	85,946	32,882
Gold (Coin and Bullion).						
United Kingdom		...	30,21,033	...	20,55,819	...
France		...	2,40,711	...	22,094	...
Other countries in Europe		...	4,01,311	...	1,08,500	...
Africa	Eastern Coast of	...	2,99,669	...	1,72,767	...
Africa	Egypt	...	26,20,564	...	17,58,138	...
Africa	Mauritius	...	100	...	...	...
Africa	Réunion	...	...	...	...	...
Africa	Other countries	...	...	...	727	...
Aden		..	1,61,818	...	2,00,952	...
Arabia		...	11,46,536	...	10,46,143	...
Ceylon		...	2,86,414	...	3,79,167	...
China		...	1,18,41,692	...	83,29,790	...
Persia		...	16,418	...	13,180	...
Straits Settlements		...	2,91,531	...	1,37,138	...
Turkey in Asia		...	95,718	...	1,16,713	...
Singapore		...	...	...	...	...
Red Sea		...	...	...	...	...
Australia		...	80,414	...	2,89,367	...
Other countries		...	...	...	...	...
Total		...	2,05,03,929	...	1,46,30,495	...

ported into British India, and the Countries from whence they are imported—contd.

78.	1876-77.		1875-76.		1874-75.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Quantity before	not available 1875-76.
Rs.		Rs.		Rs.		Rs.
1,51,229	63,671	81,687	29,139	25,789	...	28,565
1,46,178	51,096	71,357	...	...	...	...
22,251	1,840	2,700	...	...	...	5,400
16,37,966	309,191	3,18,898	536,575	3,76,961	...	7,49,580
2,15,094	10,454	11,826	43,654	31,451	...	...
94,864	2,871	4,705	12,162	12,071	...	14,530
22,67,582	439,123	4,91,173	621,530	4,46,272	...	7,98,075
72,311	19,299	85,211	8,125	28,058	...	38,300
...	56	2,176	...	...	...	1,014
90,255	9,573	57,758	2,114	13,872	...	...
...	...	...	...	...	...	31,971
...	19,215	10,909	4,924	2,815	...	...
5,485	1,979	16,018	1,099	6,824	...	6,783
3,821	979	3,459	122	1,719	...	1,270
777	7,447	2,585	792	2,137	...	5,321
1,72,649	58,548	1,78,116	17,176	55,425	...	84,659
20,30,927	...	48,06,659	...	26,72,281	...	45,46,211
36,808	...	1,12,424	...	44,645	...	2,08,555
65,335	...	51,900	...	30,590	...	33,150
2,10,743	...	2,92,245	...	98,900		
29,02,014	...	18,64,007	...	5,90,813		
...	...	1,100	...	...	...	2,97,974
...	...	...	...	60,000		
...	...	3,500	...	...		
2,27,143	...	2,30,700	...	2,77,197	...	2,76,800
8,19,196	...	12,89,573	...	16,26,333	...	20,59,017
3,68,978	...	5,29,257	...	13,25,717	...	10,66,832
84,52,123	...	40,60,289	...	1,03,29,817	...	1,08,35,838
39,030	...	1,11,594	...	1,57,875	...	8,03,362
3,13,852	...	2,80,468	...	3,65,870	...	2,30,867
1,08,905	...	5,23,123	...	5,02,111	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
2,14,219	...	2,80,276	...	2,81,662	...	5,03,757
...	...	...	...	...	...	30,000
1,57,89,273	...	1,44,37,115	...	1,83,63,811	...	2,08,92,363

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1873-74. Quantity.	1873-74. Value.	1872-73. Quantity.	1872-73. Vaule.	1871- Quantity.
PETROLEUM (Mineral Oils).					Quantity n	ot available
			Rs.		Rs.	
United Kingdom	Gals.	...	87,063	...	45,992	...
Austria	"		...	...	...	...
Africa	"	...	7,475	...	31,013	...
America	"	...	2,29,271	...	1,99,703	...
Straits Settlements	"	...	...	...	1,792	...
Other countries	"	...	27,462	...	6,732	...
TOTAL	"	...	3,51,271	...	2,85,232	...
STONE AND MARBLE (Building stones, millstones, grindstones, &c., cannot be distinguished).					Quantity	cannot be
United Kingdom	Cwt.	...	72,756	...	53,746	...
France	"	...	5,367	...	7,792	...
Italy	"	...	...	...	...	...
Mediterranean Ports	"	...	22,806	...	13,782	...
Aden	"	...	...	...	...	...
China	"	...	5,171	...	12,653	...
Straits Settlements	"	...	...	...	2,041	...
Other countries	"	...	1,620	...	6,351	...
TOTAL	"	...	1,07,720	...	96,365	...
GOLD (COIN AND BULLION).						
United Kingdom		...	27,34,720	...	75,18,174	...
France		...	21,371	...	77,057	...
Other countries in Europe		...	9,795	...	49,830	...
Africa { Eastern coast of, Egypt, Mauritius, Réunion, Other countries		...	1,87,515	...	13,00,631	...
Aden		...	3,18,295	...	2,95,375	...
Arabia		...	16,08,214	...	14,79,855	...
Ceylon		...	8,62,821	..	23,56,650	...
China		...	81,26,510	...	86,09,683	...
Persia		...	7,03,409	...	4,31,441	...
Straits Settlements		...	1,70,226	...	4,40,288	...
Turkey in Asia		...	...	...	...	...
Singapore		...	..	...	...	...
Red Sea		...	...	...	...	...
Australia		...	17,45,197	...	36,64,728	...
Other countries		...	...	...	...	...
TOTAL		...	1,64,88,073	...	2,62,23,712	...

ported into British India, and the Countries from whence they are imported—contd.

72.	1870-71.		1869-70.		1868-69.		1867-68.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
before 187	5-76.							
Rs.		Rs.		Rs.		Rs.		Rs.
1,95,580	...	18,544	...	8,555	...	42,824	...	96,236
...	...	...	...	...	...	...	...	...
7,224	...	15,452	...	...	...	23,492	...	5,824
1,52,001	...	79,622	...	30,449	...	2,74,488	...	2,41,645
8,205	...	1,370	...	...	...	...	...	4,127
41,614	...	7,986	...	1,585	...	9,924	...	17,318
4,04,624	...	1,22,974	...	40,589	...	3,50,728	...	3,65,150
given before	1875-76.							
66,446	...	55,016	...	1,34,750	...	1,12,749	...	Details not available.
12,354	...	14,402	...	10,437	...	2,841	...	
...	...	...	...	...	...	...	...	
32,934	...	17,634	..	...	...	...	...	
4,136	...	...	...	...	...	...	...	
5,997	...	7,564	...	5,778	...	7,060	..	
...	...	...	...	...	...	...	...	
34,383	...	10,099	...	6,908	...	7,080	...	
1,56,250	...	1,04,715	...	1,57,873	...	1,29,730	...	84,531
1,34,06,956	...	49,82,074	...	1,60,94,839	...	1,59,58,934	..	47,77,917
1,33,332	...	1,29,613	...	3,83,494	...	5,37,591	...	2,85,769
4,000	...	10	...	...	...	...	...	...
6,07,631	...	73,005	...	2,52,675	...	4,36,070	...	4,69,515
2,68,744	...	2,58,635	...	2,37,925	...	1,05,880	...	2,07,263
9,24,508	...	11,28,757	...	...	...	89,040	...	...
34,91,903	...	35,02,171	...	1,88,97,105	...	1,54,90,071	...	1,18,15,284
1,33,17,463	...	1,50,53,521	...	1,54,27,847	...	1,50,12,095	...	2,47,88,186
2,78,916	...	4,02,957	...	5,58,226	...	5,22,091	...	9,01,224
2,23,252	...	1,62,798	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	2,47,365	...	4,11,895	...	7,55,962
...	...	...	...	6,23,982	...	6,02,936	...	5,31,101
30,81,074	...	21,32,200	...	41,79,991	...	26,02,855	...	32,12,022
...	...	...	...	550	...	300	...	15,000
3,57,37,779	...	2,78,25,741	...	5,69,03,999	...	5,17,69,758	...	4,77,59,243

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1879-80. Quantity.	1879-80. Value.	1878-79. Quantity.	1878-79. Value.	1877- Quantity.
SILVER (COIN AND BULLION).			Rs.		Rs.	
United Kingdom		...	4,71,39,757	...	2,83,86,810	...
France		...	13,55,000	...	6,01,200	...
Italy		...	33,57,314	...	...	...
Other countries in Europe		...	450	...	410	...
Africa: Eastern coast of		...	3,90,525	...	2,63,326	...
Africa: Egypt		...	23,839	...	89,607	...
Africa: Madagascar		...	67,949	...	45,423	...
Africa: Mauritius		...	7,47,006	...	10,000	...
Africa: Réunion		...	4,16,000	...	...	...
Africa: Other countries		...	500	...	...	...
Aden		...	2,58,049	...	1,19,841	...
Arabia		...	25,87,545	...	25,19,162	...
Ceylon		...	53,62,130	...	25,74,062	...
China		...	2,82,37,143	...	1,81,18,727	...
Japan		...	22,81,000	...	3,90,000	...
Persia		...	5,38,273	...	4,84,407	...
Siam		...	63,950	...	72,965	...
Straits Settlements		...	11,58,536	...	13,88,620	...
Turkey in Asia		...	20,33,038	...	8,52,256	...
Singapore		...	...	...	...	...
Penang and Malacca		...	...	...	...	...
Red Sea		...	...	...	...	...
Australia		...	...	...	...	...
Other countries		...	32,015	...	20,175	...
TOTAL		...	9,60,50,019	...	5,59,36,991	...
BRASS.						
United Kingdom	Cwt.	8,269	4,17,797	5,895	3,11,528	8,815
Austria	"	13	1,536	31	3,941	...
Italy	"	200	23,216	169	21,282	374
Africa	"	117	3,487	...	...	66
Ceylon	"	144	11,715	181	9,769	117
China	"	1,240	54,628	208	16,714	642
Straits Settlements	"	247	24,329	214	18,318	225
Other countries	"	49	1,776	114	4,381	127
TOTAL	"	10,279	5,38,484	6,812	3,85,933	10,366
COPPER (INCLUDING COIN).						
United Kingdom	Cwt.	3,28,956	1,36,24,679	239,817	1,04,53,785	251,695
France	"	187	13,427	291	15,076	526
Italy	"	2,442	2,47,800	1,096	2,38,335	1,219
Africa: Cape of Good Hope	"	799	24,072	934	33,074	301
Africa: Eastern coast of	"	53	1,750	176	6,261	255
Africa: Egypt	"	7	1,238	837	31,752	3,343
Africa: Mauritius	"	126	3,608	40	1,369	78
Africa: Réunion	"	100	2,898	157	4,959	153
Africa: Other countries	"	...	...	274	8,959	...
Arabia	"	110	5,377	123	4,724	68
Ceylon	"	370	13,110	45	3,373	217
China	"	38,082	16,00,596	42,167	18,36,990	22,855
Persia	"	109	3,361		...	...
Straits Settlements	"	140	19,159	1,317	75,734	1,184
Japan	"	...	...	...	...	...
Australia	"	14,444	6,24,034	2,297	1,09,593	37,834
Other countries	"	248	16,438	282	17,704	375
TOTAL	"	3,86,173	1,62,01,547	289,853	1,28,41,688	320,103

ported into British India, and the Countries from whence they are imported—contd.

8.	1876-77.		1875-76.		1874-75.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.
12,71,63,297	...	7,30,52,776	...	1,97,95,662	...	4,37,68,807
11,67,120	...	11,67,920	...	14,38,800	...	8,74,630
8,56,200	...	1,03,14,700	...	11,53,210	...	...
10,000	...	2,93,050	...	2,30,068	...	2,93,287
1,78,697	...	2,32,350	...	1,12,216		
86,840	...	3,17,108	...	4,73,391		
76,088	...	58,836	...	35,791		
20,000	...	5,000	...	41,966	...	20,72,962
1,20,000	...	...	...	12,000		
...	...	5,200	...	...		
3,89,623	...	3,98,134	...	4,36,817	...	3,45,182
28,61,924	...	25,79,564	...	22,65,769	...	10,95,179
16,05,485	...	34,22,183	...	29,29,479	...	32,26,862
1,76,17,278	...	61,04,720	...	34,95,067	...	35,33,025
90,000	...	...	...	...	...	53
4,47,398	...	3,48,861	...	4,11,927	...	25,73,179
1,04,704	...	1,27,810	...	1,10,946	...	2,32,275
35,91,199	...	7,93,086	...	8,39,952	...	24,97,322
7,28,270	...	6,98,278	...	8,58,652	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
...	...	...	...	...	...	...
6,44,000	...	3,254	...	...	...	2,140
7,200	...	1,312	...	1,700	...	3,200
15,77,65,323	...	9,99,24,082	..	3,46,43,413	...	6,05,18,103
4,13,721	4,066	2,72,996	4,747	3,17,610		
...	30	3,894	85	12,253		
47,851	257	36,569	191	27,770		
2,200	316	16,197	297	12,248		
7,703	139	8,009	518	12,861		
42,501	1,581	76,664	1,288	72,418		
17,068	747	35,178	310	28,926	Figures	not available
5,391	116	4,968	24	1,150	before	1875-76.
5,36,435	7,252	4,54,475	7,460	4,85,236		
				Quantity not	available be	fore 1875-76.
1,14,77,278	221,721	1,11,67,042	178,248	90,83,871	...	64,73,788
27,899	202	14,484	44	6,265	...	...
2,61,749	74	2,757	336	28,220	...	...
10,931	231	9,584	144	6,915		
9,901	197	7,673	112	5,106		
1,54,[illegible]13	12	2,310	20	5,096	...	59,828
2,917	241	10,433	117	4,352		
5,221	198	7,346	150	7,007		
...	...	...	...	...		
2,845	124	5,011	385	17,942	...	...
12,906	326	14,996	247	8,560	...	17,564
10,68,920	17,632	8,52,125	16,301	7,87,358	...	8,31,375
...	51	2,621	27	1,407	...	[illegible],765
24,719	481	34,086	298	16,352	...	62,310
...	...	...	...	4	...	1,07,380
18,87,235	30,657	18,42,509	39,512	20,63,478	...	10,46,702
35,215	206	8,040	75	3,068	...	29,757
1,49,81,749	272,353	1,39,81,017	236,016	1,20,75,001	...	86,38,469

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.	1873-74.		1872-73.		1871-
	Quantity.	Value.	Quantity.	Value.	Quantity.
Silver (Coin and Bullion).		Rs.		Rs.	
United Kingdom	...	2,14,93,051	...	1,10,73,288	...
France	...	3,81,280	...	1,11,513	...
Italy	...	...	...	...	...
Other countries in Europe	...	5,16,200	...	10,400	...
Africa: Eastern coast of, Egypt, Madagascar, Mauritius, Réunion, Other countries	...	1,06,190	...	1,60,965	...
Aden	...	3,08,560	...	4,63,248	...
Arabia	...	12,94,264	...	14,67,565	...
Ceylon	...	31,79,021	...	18,44,765	...
China	...	91,29,668	...	16,12,730	...
Japan	...	...	...	45,700	...
Persia	...	22,64,213	...	18,05,608	...
Siam	...	2,11,598	...	1,18,790	...
Straits Settlements	...	25,16,229	...	5,98,666	...
Turkey in Asia	...	...	...	...	...
Singapore	...	...	...	...	...
Penang and Malacca	...	...	...	...	...
Red Sea	...	...	...	...	...
Australia	...	...	...	...	...
Other countries	...	36,989	...	28,900	...
Total	...	4,14,37,263	...	1,93,42,138	...
Brass.					
United Kingdom Cwt.					
Austria „					
Italy „					
Africa „				Figures not available	
Ceylon „					
China „					
Straits Settlements „					
Other countries „					
Total „					
Copper (including Coin).				Quantity not available	
United Kingdom Cwt.	...	38,54,630	...	46,92,956	...
France „	...	...	...	5,624	...
Italy „	...	...	...	...	...
Africa: Cape of Good Hope „, Eastern coast of „, Egypt „, Mauritius „, Réunion „, Other countries „	...	79,398	...	70,025	...
Arabia „	...	...	...	...	...
Ceylon „	...	...	...	23,103	...
China „	...	3,86,409	...	4,69,413	...
Persia „	...	...	...	19,035	...
Straits Settlements „	...	63,608	...	89,922	...
Japan „	...	...	...	2,13,546	...
Australia „	...	6,36,651	...	1,62,444	...
Other countries „	...	1,09,537	...	41,816	...
Total „	...	51,30,233	...	57,87,884	...

ported into British India, and the Countries from whence they are imported—contd.

72.	1870-71.		1869-70.		1868-69.		1867-68.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rs.		Rs.		Rs.		Rs.		Rs.
5,56,08,153	...	20,07,959	...	2,04,12,239	...	3,16,58,631	...	80,61,244
20,03,709	...	7,49,100	...	33,77,831	...	90,61,984	...	12,02,340
...	...	...	...	...	...	...	...	...
11,200	...	1,30,537	...	...	...	...	...	...
2,56,883	...	4,92,165	...	9,09,950	...	81,81,236	...	1,26,760
6,18,678	...	8,92,158	...	8,38,314	...	9,15,005	...	6,39,943
12,46,946	...	11,25,551	...	10,400	...	1,15,230	...	4,000
26,54,923	...	18,07,064	...	66,63,102	...	89,27,350	...	28,29,056
1,32,41,409	...	1,24,78,537	...	3,70,75,666	...	2,95,38,354	...	4,40,52,506
57,000	...	7,87,410	...	45,76,258	...	...	...	1,24,650
30,35,393	...	41,88,497	...	29,42,454	...	56,26,582	...	36,88,498
1,42,223	...	75,143	...	60,960	...	75,230	...	76,678
10,99,904	...	18,26,454	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	46,85,124	...	45,99,238	...	79,19,579
...	...	...	...	75,788	...	2,50,282	...	3,96,765
...	...	...	...	9,72,810	...	8,19,644	...	7,88,378
176	...	...	...	10,800	...	...	...	50,000
23,753	...	61,915	...	32,377	...	21,020	...	34,100
8,00,00,360	...	2,66,22,490	...	8,26,44,073	...	9,97,89,786	...	6,99,94,497
before 1875	-76.							
before 1875	-76.							
71,32,373	...	1,09,13,196	..	1,43,44,245	...	1,53,62,402	...	1,55,05,917
1,593	...	1,380	...	..	...	...	...	...
...	...	...	...	...	...	...	...	...
4,02,520	...	2,27,266	...	7,83,023	...	1,05,427	...	1,22,861
...	...	...	...	...	...	...	...	...
36,325	...	11,695	...	...	...	...	...	24,048
10,92,358	...	6,37,616	...	91,396	...	1,82,972	...	5,28,636
62,353	...	13,946	...	...	...	...	...	3,986
2,04,849	...	63,270	...	1,53,199	...	2,70,107	...	2,65,806
1,09,426	...	2,48,252	...	...	...	...	...	35,652
12,87,234	...	14,66,576	...	21,11,252	...	13,25,588	...	28,82,144
37,713	...	34,385	...	53,237	...	1,84,469	...	27,603
1,03,66,744	...	1,36,17,582	...	1,75,36,352	...	1,74,30,965	...	1,93,96,653

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1879-80.		1878-79.		1877-
		Quantity.	Value.	Quantity.	Value.	Quantity.
Lead.						
			Rs.		Rs.	
United Kingdom . .	Cwt.	67,379	9,96,944	65,750	11,06,232	52,328
France	„	4,650	49,866	110	1,585	...
Straits Settlements .	„	228	3,006	206	3,105	82
Other countries . .	„	1,223	13,142	397	5,010	347
Total .	„	73,480	10,62,958	66,463	11,15,932	52,757
Quicksilver (Mercury).						
United Kingdom . .	Lbs.	80,172	94,188	76,503	1,11,653	131,403
China	„	371.250	4,06,157	168,381	2,69,751	76,575
Other countries . .	„	79,971	88,091	6,000	6,643	3
Total .	„	531,393	5,88,436	250,884	3,88,047	207,981
Spelter (Zinc).						
United Kingdom . .	Cwt.	127,054	14,42,437	128,919	15,56,619	129,726
Other countries . .	„	84	1,162	742	8,853	554
Total .	„	127,138	14,43,599	129,661	15,65,472	130,280
Iron.						
United Kingdom . .	Cwt.	2,096,709	1,22,10,441	2,344,055	1,43,33,135	2,428,036
France	„	...	...	359	1,695	266
Germany	„	2,628	27,793	5,846	39,150	1,316
Sweden	„	...	...	...	...	...
Africa	„	1,839	4,708	1,072	2,123	1,371
Arabia	„	1,036	3,546	1,638	7,669	382
Ceylon	„	6,339	30,231	6,845	36,223	5,254
Straits Settlements . .	„	1,198	8,567	1,715	14,310	312
America	„	...	...	199	2,719	...
Australia	„	...	...	...	...	...
Other countries . .	„	1,407	8,561	3,577	23,127	784
Total .	„	2,111,156	1,22,93,847	2,365,306	1,44,60,151	2,437,721
Tin.				Quantity	for Spelter	Iron and
United Kingdom . .	Cwt.	639	26,297	1,842	52,279	703
Ceylon	„	457	3,957	41	1,590	...
Siam	„	96	3,900	97	4,852	...
Straits Settlements . .	„	19,105	9,25,883	33,464	14,54,511	46,119
Other countries . .	„	543	28,422	45	4,169	1,849
Total .	„	20,840	9,88,459	34,989	15,17,401	48,671

ported into British India, and the Countries from whence they are imported—**contd.**

78.	1876-77.		1875-76.		1874-75.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
					Quantity before 18756.	not available
Rs.		Rs.		Rs.		Rs.
9,64,885	40,326	7,22,410	35,911	6,25,999		5,05,055
...	...	...	...	...		
1,535	110	2,038	138	2,503		
4,681	39	1,314	167	2,487		4,377
9,71,101	40,475	7,25,762	36,216	6,30,989		5,09,432
1,75,457	91,706	1,61,744	463,763	9,49,149	158,044	1,58,500
1,13,536	114,150	1,93,029	54,765	1,13,935	...	...
8	11,325	14,550	5,770	12,021	2,700	2,700
2,89,001	217,181	3,69,323	524,293	10,75,105	160,744	1,61,200
17,87,937	95,839	14,26,217	58,805	8,22,312		4,69,142
6,593	754	10,981	313	4,201		5,502
17,94,530	96,593	14,37,198	59,118	8,26,513		4,74,644
1,43,01,927	2,227,744	1,51,74,105	2,007,095	1,41,53,521		1,20,06,009
2,957	215	1,534				5,422
6,787						11,661
...						...
3,613	702	1,054				43,084
7,887	2,026	6,093	1,134	2,225		...
25,911	9,853	45,363	10,888	50,572		37,667
178	5,418	32,015	1,304	12,922		42,794
	...	...	1,071	11,687		18,518
	2,000	3,000	...	...		54,143
5,351	3,235	20,893	2,354	15,051		43,946
1,43,55,611	2,251,193	1,52,84,057	2,023,846	1,42,45,978		1,22,63,244
Tin not avai	able before 18	75-76.				
25,496	1,325	42,141	4,100	98,779		4,08,994
	...	...	130	4,344		16,080
	235	12,247	397	17,083		8,244
21,19,428	35,685	17,49,798	81,479	15,67,849		11,71,648
76,647	51	3,757	53	4,307		5,314
22,21,571	37,296	18,07,943	36,159	16,92,362		16,10,250

Statement of the Quantity and Value of the principal Mineral Productions im

Countries whence imported.		1873-74.		1872-73.		1871-
		Quantity.	Value.	Quantity.	Value.	Quantity.
LEAD.					Quantity n	ot available
			Rs.		Rs.	
United Kingdom . .	Cwt.	...	3,68,431	...	6,29,598	...
France	,,	...	...	...	...	...
Straits Settlements . .	,,	...	...	...	...	...
Other countries . .	,,	...	14,510	...	8,219	...
TOTAL .	,,	...	3,82,941	...	6,37,817	...
METALS—QUICKSILVER (Mercury).						
United Kingdom . .	Lbs.	137,702	1,37,702	160,487	1,60,487	338,673
China	,,	4.200	4,200	..	...	...
Other countries . .	,,	1,125	1,125	3,760	3,760	14,625
TOTAL .	,,	143,027	1,43,027	164,247	1,64,247	353,298
SPELTER (Zinc).						
United Kingdom . .	Cwt.	...	4,87,094	...	12,14,965	...
Other countries . .	,,	...	8,134	...	4,201	...
TOTAL .	,,	...	4,95,228	...	12,19,166	...
IRON.						
United Kingdom . .	Cwt.	...	75,30,773	...	72,76,799	...
France	,,	...	...	...	9,356	...
Germany	,,	...	...	...	20,016	...
Sweden	,,	...	...	...	...	...
Africa	,,	...	76,014	...	37,543	...
Arabia	,,	...	...	...	...	...
Ceylon	,,	...	26,784	...	14,652	...
Straits Settlements . .	,,	...	69,026	...	58,298	...
America	,,	...	...	...	.	...
Australia	,,	...	36,739	...	21,934	...
Other countries . .	,,	...	39,488	...	32,834	...
TOTAL .	,,	...	77,78,824	...	74,71,432	...
TIN.				Quantity	for Spelter,	Iron and
United Kingdom . .	Cwt.	...	3,36,217	...	1,45,092	...
Ceylon	,,	...	...	...	1,838	...
Siam	,,	...	...	...	23,733	...
Straits Settlements . .	,,	...	12,92,872	...	6,80,571	..
Other countries . .	,,	...	24,895	...	3,734	...
TOTAL .	,,	...	16,53,984	...	8,54,968	...

ported into British India, and the Countries from whence they are imported—concld.

72.	1870-71.		1869-70.		1868-69.		1867-68.	
Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
before 1875-76.								
Rs.		Rs.		Rs.		Rs.		Rs.
5,69,052	...	4,52,593	...	3,90,262	...	3,82,216	...	1,34,960
...	...	45,864	...	32,633	...	...	...	...
1,098	...	4,557	...	797	...	33,445	...	...
3,816	...	30,426	...	3,002	...	2,071	...	85,637
5,73,966	...	5,33,440	...	4,26,694	...	4,17,732	...	2,20,597
3,38,673	129,526	1,29,526	140,103	1,47,603	283,245	3,28,245	161,195	1,63,820
...	...	...	...	...	75,000	67,500	...	
14,625	11,625	11,625	7,500	7,500	22,500	22,500	62,625	60,000
3,53,298	141,151	1,41,151	147,603	1,55,103	380,745	4,18,245	223,820	2,23,820
12,32,077	...	12,10,355	...	13,52,985	...	19,23,454	...	20,13,358
5,837	...	11,692	...	17,469	...	4,596	...	29,232
12,37,914	...	12,22,047	...	13,70,454	...	19,28,050	...	20,42,590
80,46,645	...	84,51,764	...	1,11,66,420	...	1,35,96,475	...	1,36,81,901
1,216	...	5,045	...	24,474	...	20,891	...	2,817
...	...	25,658	...	38,291	...		...	...
...	...	1,09,498	...	2,81,722	...	5,33,154	...	5,07,098
95,886	...	1,37,834	...	2,51,846	...	1,85,832	...	1,55,323
...	...	...	...	...	...	...	...	...
23,322	...	16,142	...	10,318	...	27,109	...	23,800
20,779	...	39,652	...	25,405	...	62,419	...	40,620
...	...	4,509	...	...	...	...	...	2,408
19,368	...	10,446	...	35,946	...	20,987	...	30,279
16,804	...	21,016	...	46,443	...	70,789	...	1,68,758
82,24,020	...	88,21,564	...	1,18,80,865	...	1,45,17,656	...	1,46,13,004
Tin not available before 1875-76.								
2,52,217	...	1,89,941	...	3,35,960	...	4,81,789	...	2,09,663
...	...	5,036	...	23,018	...	1,911	...	2,002
70,893	...	21,226	...	...	...	20,593	...	3,241
10,08,224	...	11,65,681	...	11,98,353	...	9,36,334	...	7,40,504
21,633	...	35,538	...	6,446	...	20,125	...	43,151
13,52,967	...	14,17,422	...	15,63,773	...	14,60,752	...	9,98,561

APPENDIX B.

Statement showing the total quantity and value of Coal, Coke and Patent Fuel imported into India from Foreign Countries in each official year from 1875-76 to 1880-81.

		1875-76.		1876-77.		1877-78.		1878-79.		1879-80.		1880-81.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.	Tons.	Rs.
Coal	General Trade	3,68,737	63,47,105	5,03,430	89,44,792	5,95,328	99,46,149	4,69,507	87,40,412	5,70,455	1,09,13,459	6,70,300	1,20,49,180
	Government Stores	19,743	1,28,508	19,954	2,38,298	8,403	1,03,275	3,520	74,029	17,179	3,41,359	*45,290	*8,10,600
	TOTAL	3,88,480	64,75,613	5,23,384	91,83,090	6,03,731	1,00,49,424	4,73,027	88,14,441	5,87,634	1,12,54,818	7,15,590	1,28,59,780
Coke	General Trade	10,407	2,52,467	16,149	3,69,153	5,831	1,33,174	3,828	88,753	7,842	2,20,226	6,505	1,79,593
	Government Stores	888	31,178	629	10,228	173	5,730	319	7,680	658	17,281	...	...
	TOTAL	11,295	2,83,645	16,778	3,79,381	6,004	1,38,904	4,147	96,433	8,500	2,37,507	6,505	1,79,593
Patent Fuel	General Trade	4,285	55,780	170	3,160	98	2,224	2,625	65,605	12,626	2,48,390	6,963	1,69,779
	Government Stores	...	...	1 Cwt.	2	...	...	...	...	...	...	...	...
	TOTAL	4,285	55,780	170-1	3,162	98	2,224	2,625	65,605	12,626	2,48,390	6,963	1,69,779

* Includes figures for Coke and Patent Fuel.

N. B.—Appendix A does not include Coal, &c., imported on account of Government.

APPENDIX C.

Statement of Coal carried from the Coal-fields by the East Indian and Great Indian Peninsular Railways respectively for the years from 1868 to 1880 inclusive.

	East Indian Railway.[1]			Great Indian Peninsula.			Grand Total.
	Public coal.	Locomotive coal.	Total.	Warora.	Mopani.	Total.	
	Tons. Cwt. Qr.	Tons. Cwt. Qr.	Tons. Cwt. Qr.	Tons. Cwt. Qr.	Tons. Cwt. Qr.	Tons. Cwt. Qr.	Tons. Cwt. Qr.
January to December 1868	258,266 19 0	201,141 5 0	459,408 4 0	...	...	...	459,408 4 0
„ 1869	285,121 13 0	267,256 19 0	552,378 12 0	...	...	...	552,378 12 0
„ 1870	284,749 0 0	223,839 2 2	508,588 2 2	...	78 0 0	78 0 0	508,666 2 2
„ 1871	266,253 16 0	149,547 1 2	415,800 17 2	...	5,947 0 0	5,947 0 0	421,747 17 2
„ 1872	302,135 2 0	132,745 3 0	434,880 5 0	...	7,332 0 0	7,332 0 0	442,212 5 0
„ 1873	418,000 14 0	134,378 1 2	552,378 15 2	...	9,454 0 0	9,454 0 0	561,832 15 2
„ 1874	505,519 0 0	184,041 13 2	689,560 13 2	54 0 0	15,107 0 0	15,161 0 0	704,721 13 2
„ 1875	515,816 5 0	114,097 5 3	629,913 10 3	11 0 0	19,170 0 0	19,181 0 0	648,094 10 3
„ 1876	520,222 15 0	122,802 7 0	643,025 2 0	1,089 0 0	13,912 0 0	15,001 0 0	658,026 2 0
„ 1877	623,533 13 0	189,532 0 0	813,065 13 0	28,446 0 0	12,972 0 0	41,418 0 0	854,483 13 0
„ 1878	692,454 17 0	186,732 1 0	879,186 18 0	35,924 0 0	10,384 0 0	46,308 0 0	925,494 18 0
„ 1879	747,664 19 0	155,284 7 0	902,949 6 0	25,078 0 0	10,618 0 0	35,696 0 0	939,645 6 0
„ 1880	732,226 14 0	175,266 17 3	907,493 11 3	16,039 0 0	9,401 0 0	25,440 0 0	932,933 11 3
Total ...	6,151,965 7 0	2,236,664 4 2	8,388,629 11 2	106,641 0 0	114,375 0 0	221,016 0 0	8,609,645 11 2

[1] The amounts carried respectively from the Raniganj and Karharbari fields are not separated in the returns which have been received.

APPENDIX D.

List of Collieries in the Bengal Presidency and the Central Provinces for the Calendar year 1879.

Provinces and Districts.			Name of Mine.	Output of coal in the year 1879.	Average annual output of coal in the 3 years previous to 1879.
				Tons.	Tons.
Bengal.	Bardwan ...	1	Raniganj	51,450	45,128
		2	Mangalpur	24,233	24,066
		3	Chaukidanga (*a*)	...	...
		4	Raghunathchak (*a*)	...	...
		5	Siarsol	52,729	41,830
		6	Jemeri	28,681	25,652
		7	Nimcha	11,561	5,314
		8	Hatinal	420	1,926
		9	Lalbazar	1,698	†
		10	Bansra	30,000	30,000
		11	Nija	13,000	12,000
		12	Dhadkia	31,561	27,747
		13	Benali (*a*)	...	...
		14	Madhubpur	24,752	9,599
		15	Dhosal	1,928	1,928
		16	Sanktoria	33,065	28,471
		17	Haripur (*a*)	...	...
		18	Belrui	24,934	16,587
		19	Dhosal	24,900	†
		20	Sibpur	17,418	10,714
		21	Satpukuriya (*a*)	...	...
		22	Lachipur	275	†
		23	Rampit mathi (*b*)	...	...
		24	Bamundihi	2,200	15,413
		25	Do.	2,411	447
		26	Do.	1,082	1,082
		27	Do.	1,321	535
		28	Bamundhea	5,534	†
		29	Jotjanaki	22,000	18,000
		30	Kumardi (*c*)	...	...
		31	Lakhmipur	3,724	52,424
		32	Niamatpur	21,970	†
		33	Charanpur	24,380	13,796
		34	Deziragarh	9,761	†
		35	Banbahal	1,928	714
		36	Kalipahari	1,750	2,142
		37	Narsamda	3,569	5,002
		38	Pura	19,286	15,826

(*a*) These mines are now closed.
(*b*) Closed from the 26th August 1878.
(*c*) These mines are now closed. None of them have been worked for the last three years.
† No information available.

List of Collieries in the Bengal Presidency and the Central Provinces for the Calendar year 1879.—concluded.

Provinces and Districts.		Serial number.	Name of Mine.	Output of coal in the year 1879.	Average annual output of coal in the 3 years previous to 1879.
				Tons.	Tons.
Bengal.	Bardwan ...	39	Sodepur	16,765	4,806
		40	Bamundiya	1,573	1,156
		41	Lachipur	1,018	...
		42	Mohanpur	†	...
		43	Bhutra	785	...
		44	Chatapatar	7,501	...
		45	Kalipahari	2,235	...
		46	Do.	857	...
	Hazaribagh.	47	Kuldiha	59,198	48,777
		48	Karharbari	140,804	1,55.209
		49	Serampur	90,425	1,23,744
		50	Bariadih	45,899	68,787
		51	Serampur (*a*)	...	...
	Lohardugga ...	52	Rajhera (Daltonganj)	892	†
	Manbhum ...	53	Khomerdobio	26,362	†
		54	Agerkuri	25	616
		55	Makma	136	124
		56	Merya	1,024	2,525
		57	Nawadanga	1,455	620
		58	Kapashara	200	142
		59	Do.	100	130
		60	Kowari (Chornee Nalla)	111	31
		61	Do. (Pita Kewary)	151	28
		62	Kanjawa and Kasunda	10	...
			Total for Bengal	891,047	813,040
Central Provinces.	Narsingpur ...	63	Mohpani . 10,617 12,421		
	Chanda ...	64	Warora . 22,898 33,951		
		2	Total for the Central Provinces	33,515	46,372
			GRAND TOTAL	924,562	859,412

(*a*) These mines are now closed; none of them have been worked for the last three years.

† No information available.

APPENDIX E.

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APPENDIX F.

Vocabulary of Hindustani Mineralogical and Mining terms, &c.

Abrak—Mica, commonly but incorrectly called Talc.
Ágar—Pan for evaporation in the saltpetre manufacture.
Áhak.—Quick lime.
Akík—Carnelian, Agate, &c.
Álmás—Diamond.
Ásahar—Lit., giant's bone; applied to cellular travertin.

Bilaur—Rock crystal.
Buthni Sajji—Devil's (inferior) sajji (*i.e.*, sodium carbonate).

Chakmak—Flint.
Chamak pathar—Magnetic oxide of iron.
Chándí—Silver.
Chikni matti—Clay, fire-clay.
Chílá—Applied to open superficial workings as those for diamonds at Panna.
Chúli—Bloom or ball of iron (Bandelkhand).
Chúná—Lime.
Chúnri—Garnet.

Dár Chikná—Corrosive sublimate.
Dháo—Iron ore in form of sand.
Dhát or Dhánt—Metal.
Dhúdiá pathar—Opal.
Duin or Drun—Wooden cradle used by gold-washers.

Fan—A whetstone.
Fastiki—A kind of emerald.
Fíroza—Turquoise.

Gach—Gypsum. Mortar.
Gandhak ka tez-áb—Sulphuric acid.
Gárá—Mud.
Gerú—Red ochre.
Ghairá—Deep mines.
Ghori—White carnelian; a kind of porcelain.
Giri. Bloom or ball of iron.
Godant—Gypsum. Alabaster; also yellow orpiment.
Gomed sannibh—Chalcedony or opal.
Gser—(Thibetan) gold.
Gúlmidak—Hyacinth (*i.e.*, Zircon) or an imitation of it.

Hartál—Orpiment.
Hírá—Diamond.
Hírá-kasís—Copperas.

Ingáni—Oxide of manganese.
Ispát—Steel.

Jamsán—An alkaline earth or soil.
Jast—Zinc, pewter.
Jhámá—Pumice stone. Vitrified bricks.
Jor—Belows of an iron furnace.

Káhi—Iron sulphate.
,, *lál*—Bichromate of potash.
,, *máti*—Sulphate of iron earth.
,, *sabz*—Impure green vitriol.
,, *saféd*—White anhydrous iron sulphate.
,, *siyá*—Black iron sulphate.
,, *zard*—Yellow variety of Kahi safed.
Kah-ruba—Amber. *Lit.*, grass attractor.
Kakrú—Gravelly matrix of diamond at Panna.
Kalái—Whitening; also slaked lime.
Kalar—Saline efflorescence—*Reh.*
Kán or Khan—A mine.
Kankar—A pebble: Nodular limestone.
Kánch—Glass.
Karguha—Iron-furnace tongs.
Karsi—A variety of gypsum from Spiti.
Kásís—Copperas or iron sulphate.
Katouti—Gold washing trough used in Moradabad.
Kaya—Alloy of zinc, tin, and copper.
Khádar—Low or alluvial land near banks of rivers.
Khák—Dust.
Khár—Alkali, potash, or soda.
Kharí matti—Chalk or white clay. Pipe clay.
Kháti— Lit., Cutters, quarrymen.
Kheri—A kind of iron or steel.
Khit—Slag from iron furnace, Bundelkhand.
Kirasi—A kind of emerald.
Koela—Coal, properly charcoal.
Kulhári—Axe.
Kurund—Corundum.
Kyári—Shallow pan for evaporating salt.

Láiri—An inferior ruby or garnet.
Lajwárd—Lapis lazuli.
Lál—Ruby.
Lasniyán—Cat's eye.
Lohá—Iron.
Lohár—Blacksmith.
Lohá chúr—Iron filings.
Lon—Salt.
Lohakhar—Cyanide of potassium.
Lún—Salt.

Mákol—Granular gypsum.
Mánik—Ruby.
Mankà—Cut agates and beads, &c.
Matti ká tel—Earth-oil, petroleum.
Miknátis—Magnet or loadstone.
Missi safed—Oxide of zinc.

Missi siyá—Oxide of manganese.
Mitti ká tel—Petroleum.
Mitti subz khandáni—Fuller's earth.
Momiyai— *Lit.*, Mummy-like, asphalt. bitumen is used as a drug.[1]
Multáni matti—Fuller's earth.
Morai—Iron-refining furnace.

Nar—Iron furnace.
Nila thothá—Blue vitriol.
Nilam Sapphire.
Nil wilayiti—Blue ferrocyanide of iron.
Nimak—Salt.

Pahár—Hill, sometimes used technically by miners, as 'country' is by European miners, meaning useless matrix, &c.
Panná—Emerald.
Pára—Mercury.
Patthar—Rock, stone.
Patthar-i-artish—Fireworks.
Papri—Any thin shell like substance. is applied to thin encrustations of salt on margins of lakes.
Phitkiri—Alum.
Phul Dhtáu—Bismuth ?
Píli mitti—Yellow ochre.
Pítal—Brass.
Pukhráj—Topaz.
Púng (in Assam)—A spring of oil or salt, &c.

Rág—A flaw in a jewel.
Raihani—A kind of emerald.
Rál—Pitch, resin.
Rangá—Solder.
Ranga—Tin used for lining copper vessels.
Ratan—A jewel, a precious stone.
Reg-tila—Auriferous sand.
Reh—Saline efflorescence in the soil.
Ret—Sand.
Roin—Bell-metal.
Rol—Alum shale.
Rúpá—Silver.
Rúpamakhi—Iron pyrites.

Sabzá—Emerald.
Safedá—Lead carbonate.
Safed-soná—Platinum.
Shail—Slate or schist. a mountain.
Sáitá—Cobaltite. the so-called Syeporite.
Sajjí—Sodium carbonate.
Sálájit—Alum. Lit., *sila*, a stone and *jit* essence ; sometimes applied to lignite or bitumen.
Sandháb—Rock salt.
Sandhur—Red lead.
Sang-i-akík—Carnelian.
,, *asshar*—Silica.
,, *úsiya*—Millstone grit.

1 The original drug is said to have been prepared from Egyptian mummies, and subsequently to have been prepared by boiling down and extracting the essence of Abyssian boys. Since this last source of supply has become scarce, natural bituminous exudations have been substituted.

Sang-i-basri—Zinc.
,, *Chakmak*—Magnetic iron.
,, *irmali*—A fossil.
,, *jaráhat*—A fossil.
,, *jehanam*—Lit., hell-stone, lunar caustic.
,, *larzan*—Flexible sandstone.
,, *marmar*—Marble.
,, *mehtab*—Garnet.
,, *musa*—Jet, a black stone.
,, *palaun*—French chalk.
,, *pathanni*—Bloodstone.
,, *sabz*—Silicate of iron?
,, *shadnaj*—Nummulite.
,, *sitara*—Aventurine quartz.
,, *Sulaimáni*—Onyx, &c.
Sankyá—Arsenic.
Sanrsi—Iron tongs.
Sehta—See *Saita*.
Shaháb—Meteor.
Shangarf—Cinnabar, vermilion.
Shankanrái—Fire-clay.
Shorá kalmi—Saltpetre (refined).
Sil—Stone for grinding paints, &c., sharpening knives, &c.
Silkari—French chalk or steatite.
Símá—Mercury.
Sisá—Lead.
Sohágá—Borax.
Soná—Gold.
Sonmákki—Copper pyrites or chalcopyrite.
Surb—Lead.
Surkhí—Pounded brick.
Surmá—Stibnite or antimony sulphide, incorrectly applied to galena.
,, *Isfahani*—Micaceous iron.
,, *safed*—Iceland spar.
Surr—Brine well, Rajputana.

Tabashír—A silicious secretion in bamboo.
Támá —Copper.
Támrá— Garnet.
Tansála—Smoky quartz.
Tel gandhak—Petroleum.
Tezáb gandhak—Sulphuric acid.
,, *nimak*—Hydrochloric acid.
,, *shorá*—Nitric acid.
,, ,, *wa Kahi*—Nitromuriatic acid or aqua regia.
,, *sirke ká*—Acetic acid.
Trun?—Cradle for gold-washing on Indus.

Yákút—Spinel, garnet.
Yákút rumáni—A first-class ruby.
Yamni—Agate or pebble.
Yashm—Different green stones, jade, prase, &c.

Zahr muhra—Lit., poison-killer, serpentine.
Zangár—Verdigris, rust.
Zumurud—Emerald.

APPENDIX G.

Values of certain Weights, Measures and Coins mentioned in this Volume.

Chatánk (Chittack)=1 oz. 17½ dwt. troy.

Fanam—A coin, sometimes gold, formerly used in Southern India; value two pence according to Heyne, but it varied.

Goss—An old measure of distance in Madras; it was equal to eight miles.

Háth—Cubit. A somewhat variable unit of measurement, being equal to the distance from the elbow to the tips of the fingers, to which is sometimes added the breadth of the palm,—say in all from 18 to 20 inches, sometimes even 22 inches.

Kandy—A Southern India unit of weight = 500 lbs., but varies locally.
Kos—A measure of distance equal to two miles, but varies between 1½ and 3.

Maund (*man*)—The Government maund=40 seers, or 82$\frac{2}{7}$ pounds; there are therefore about 27¼ maunds in a ton. The values of local maunds vary from 16 seers upwards.

Pagoda—A gold coin worth 8*s.* 9*d.*, but varies locally.

Rati—Supposed to be equal to the weight of the seed of the *Abrus precatorious.* The true value has varied much from time to time. According to Tavernier in 1665 and Captain Hamilton in 1727, it weighed 3½ grains (see page 21). Mr. Thomas says the old Hindu rati=1·75 grains, and in Akbar's time 1·9375 grains. At present it=1·88 Troy.

Tikal—A Burmese coin=Re. 1-4 annas, say 2*s.* 6*d.*

Tola=7 dwt. 12 grains Troy.

Viss—A Burmese unit of weight=3·6516 lbs.

The following table gives the equivalents both in troy and avoirdupois of the standard weights in British India:—

1 Dhan or grain		= $\frac{15}{32}$ grain	troy	= $\frac{3}{175}$ dr.	avoir.
4 Dhans	= 1 Rati	= $1\frac{7}{8}$ „	„	= $\frac{12}{175}$ „	„
8 Ratis	= 1 Masha	= 15 „	„	= $\frac{96}{175}$ „	„
12 Mashas	= 1 Tola	= 7 dwt. 12	„	= $6\frac{102}{175}$ „	„
5 Tolas	= 1 Chittack	= 1 oz. 17½ dwt.	„	= $2\frac{2}{35}$ oz.	„
16 Chittacks	= 1 Seer	= 2¼ lbs.	„	= $2\frac{2}{35}$ lbs.	„
40 Seers	= 1 Maund	= 100 „	„	= $82\frac{2}{7}$ „	„

35 Seers are exactly equal to 72 lbs. avoir., and the ton contains 27·23 maunds.

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PART II.—PLACES.

[In this section some vowel accents are given to indicate the pronunciation where likely to be mistaken; transliteration is not attempted.]

D.

E.

Government Central Press.—No. 6 S. G. S.—11-12-81.—1,000.